Populations

(Level 3)

Teacher's Guide

Chester A. Lawson
Robert Knott
Robert Karplus
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Marshall Montgomery

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Preface: From SCIS to SCIIS

Over the past twenty years almost a hundred curriculum projects—the majority in science—germinated on the educational landscape. Some withered, some bloomed, and some not only thrived but went on to propagate successful offspring. Among the latter has been the Science Curriculum Improvement Study (SCIS), which grew out of Robert Karplus's early studies of elementary school children and science learning in the 1960s. Funded by the National Science Foundation, and eventually housed at the Lawrence Hall of Science, University of California at Berkeley, the SCIS program became one of several curriculum projects that have markedly changed the direction of elementary science education in the 1970s. After extensive testing with thousands of students and teachers, the first commercial edition of SCIS was published by Rand McNally in 1970–72.

The educational impact and acceptance of SCIS was rapid and widespread. The insights, commitment, and enthusiasm of the SCIS developers were passed on to the teachers using the program—directly and through workshops, in-service training, and visitation programs at the Lawrence Hall. These efforts were significantly reinforced by the publisher, who sponsored additional programs for teachers, set up information and awareness centers, provided consultants, and serviced thousands of schools with its representatives. In less than three years SCIS clearly established itself as a program to emulate. No other available materials provided science educators with so much flexibility in subject matter, classroom materials, and teaching strategy, within a clearly defined conceptual framework. No other program so explicitly set scientific literacy as its overall goal for children—and then earned the documentation (mostly from independent sources) to show achievement of that goal. No other program introduced children to the life sciences by bringing live organisms into the elementary classroom for direct observation and study. And no other program that focused on *doing,* rather than reading about, science was more widely adopted and used in the schools.

For these reasons, SCIS has been a challenging program and, at the same time, one that has been a pleasure to teach and to learn from. The challenge lay in the need for the developers, the publisher, and teachers to give something more in terms of time and effort, and to effectively create, deliver, and present to students the concepts and activities embodied in SCIS. For example, one of the salient and essential features of the program is the presence of live organisms in the classroom; the culturing, scheduling, procurement, use, care, and maintenance of selected plants and animals, no matter how hardy, required a commitment over and above that needed in a "read-about" science program.

On the other hand, that SCIS has been a pleasure to teach is a judgment that comes from thousands of educators and children who have used it. An overwhelming majority have told the publisher and the authors that student interest, enthusiasm, and achievement have been markedly increased in their classes—and not only in terms of science. Language and communication skills have improved, as supported by research. Ability and willingness to observe, measure, collect data, organize information, reason, interpret, and weigh evidence have been characteristic of SCIS learners. Anticipating and then witnessing these outcomes in the classroom helps to make teaching what it at least occasionally needs to be—a joyful experience.

During the 1975–76 school year Rand McNally invited approximately 500 elementary specialists and teachers using SCIS in a wide variety of locations and educational environments to review the materials and comment critically from their own experiences. They did so in person and in writing, and the resulting feedback has provided a basis for thorough revision by members of the original SCIS author team. Working together, the authors and the publisher began developing the new program you now have in hand. The task encompassed far more than merely remodeling the existing activities, books, and equipment. New activities, concepts, themes, learning components, design, packaging, sources of supply, delivery systems, and services to support teachers — these and other features of the new program were scrutinized and tested in schools or laboratories, and measured against the expressed needs of the schools.

The end result is the Rand McNally SCIIS program.

We are pleased with it. We are confident that it will provide you and your students with even greater opportunities for learning and enjoyment in science—and in ways related to other disciplines—than did its predecessor. And we want to hear from you about your experiences with it (see the Evaluation Response Form, drawer 1, in the kit).

Finally, our thanks to the many teachers, parents, and children who voluntarily give us the benefit of their comments. We would like the reader to join them—as a user and as a friendly critic—in the ongoing task of improving science education, with SCIIS.

A note about the title and logo

We seem to be nearing a time when the supply of possible acronyms for educational programs, projects, and organizations will be exhausted. Rather than contribute to a further drain on the supply, we thought it singularly appropriate to retain much of what "SCIS" has been—in name as well as in substance. We saw the task as one of improving SCIS *from within* a conceptual and physical framework that had already proven itself in the classroom, rather than simply adding on from outside or giving the impression that we were starting from scratch again. Hence, SCIS became SCIIS, with another I inserted. And something resembling the original "snowflake" survives in the logo.

For the literal-minded, the new I may serve to represent further improvement, or more innovation, or (with its partner) a two (II). Thinking about and debating such fine points provided hours of recreation for editors, advertising staff, and project management. We would prefer that you call the program "Rand McNally SCIIS" to avoid confusion with the earlier SCIS or with other products now using a similar name.

For the Authors—
Herbert D. Thier

For Rand McNally—
William Miller

August, 1977

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An Introduction to SCIIS

The Conceptual Framework

Diversity and change—in the landscape, in cloud formations, at the zoo, in a jar of sugar water forming rock candy—attract children's attention and awaken their interest. Curious about their surroundings, children naturally seek to describe and sort the diverse animals, plants, and nonliving materials they discover. In this respect they resemble scientists, who try to understand the basic conditions governing change.

THE GOAL: SCIENTIFIC LITERACY

Through investigation, scientists' understanding of nature advances from simple hypotheses to complex theories. Similarly, children's thinking advances from the concrete to the abstract as they accumulate experiences and ideas. They develop more effective techniques for observing and testing nature. In other words *they become scientifically literate*.

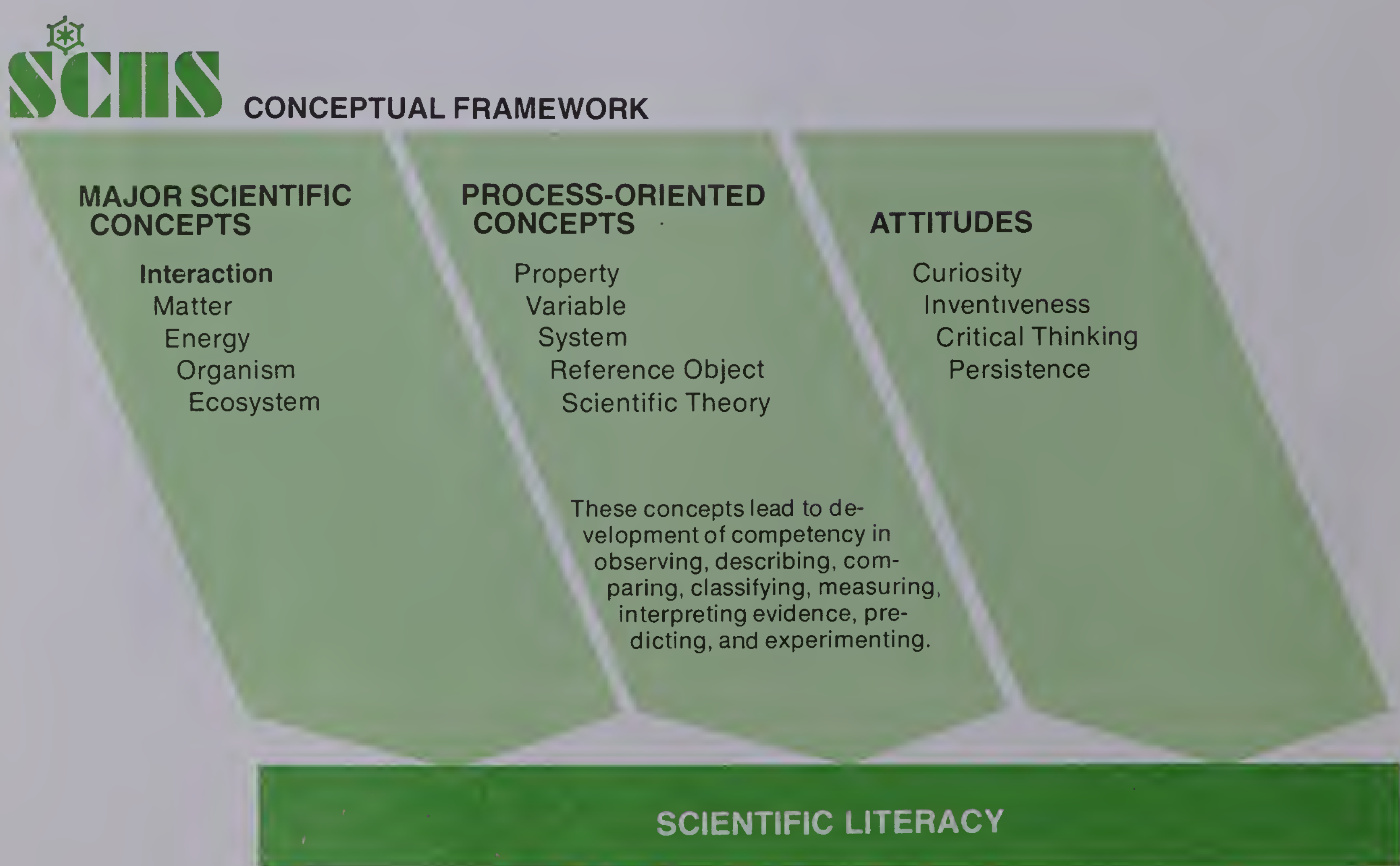
Scientific literacy derives from basic knowledge, investigative experience, and curiosity. In the SCIIS program, these three factors are integrated, balanced, and developed through the children's involvement with basic scientific concepts, process-oriented concepts, and challenging problems for investigation.

CONCEPTS, PROCESSES, AND ATTITUDES

Educators frequently distinguish among content learning, process development, and attitude formation when they describe an educational program or evaluate its outcomes. The SCIIS program combines these three factors into an integrated whole, matching the way children learn. Children are introduced to scientific content through firsthand experiences—with magnets, gears, fish, crickets, and a wide range of other living and nonliving materials.

In the course of their investigations, children engage in observation, measurement, interpretation, prediction, and other processes essential for the development of scientific literacy.

Finally, the SCIIS program helps children form positive attitudes toward science as they explore phe-



nomena. Using their own ideas and preferences, children learn to cope confidently with new and unexpected findings by sifting evidence and forming conclusions—thus removing the "magic" from science.

Major Scientific Concepts *Interaction.* The concept of *interaction* is central to modern science—and therefore also to the SCIIS program. This concept embodies the scientific view that changes in nature take place because objects interact in reproducible ways when conditions are controlled. In the scientific view, changes do not occur because they are preordained or because a "spirit" or other power within objects influences them capriciously.

When objects or organisms do something to one another that brings about a change, we say that an interaction has occurred. When you clap your hands, they interact with one another and the air. The observed changes, the sensation in your palms, and the sudden sound are evidence of interaction.

Children can easily observe and use such evidence. They can watch a guppy eat a daphnia, hear bubbles when seltzer tablets dissolve, spin a compass pointer with a magnet, and detect the odor of decomposing organic materials. As they advance from dependence on concrete experiences to the ability to think abstractly, children can identify the conditions under which interactions occur and predict their outcomes.

In SCIIS, four major scientific concepts elaborate the interaction theme—*matter, energy, organism,* and *ecosystem*. Children's experiences and investigations in the six units that make up the physical/earth science sequence are based on matter and energy.

Organism and ecosystem provide the framework for the six units in the life/earth science sequence. Additional concepts are described in the appropriate Teacher's Guides.

Matter. Matter, or material, is introduced in the SCIIS program through the solids, liquids, and gases in the environment. These interact with human sense organs and with each other. Material objects can be described and recognized by their color, shape, weight, texture, and other properties. As children investigate changes in objects in the SCIIS physical/earth science sequence, they become aware of the diversity of interacting objects and their properties.

Energy. Energy is the inherent ability of a system to bring about changes in itself or in the state of its surroundings. Some familiar energy sources are the natural gas used to heat a kettle of water, the horse used to pull a plow, the unwinding spring that operates a clock, and the discharging battery in a pocket radio. The complement of an energy source is an energy receiver, such as the football kicked by a player or the ice cube placed in warm water. The interaction between energy source and receiver results in energy transfer.

Organism. An organism is an entire living individual—plant or animal. It is composed of matter, and it uses the energy from its food to develop, grow, and be active. The organism concept represents a fusion of the matter and energy concepts, but it is much broader than the sum of its parts. An essential factor is the organization of matter into cells and other structures that assure continuity of life from generation to generation.

Ecosystem. Awareness of the interactions between organisms and the environment leads to the ecosystem concept. As children observe living plants and animals in the classroom or out-of-doors, they notice the amazing diversity of organisms and their life cycles. They observe how plants and animals interact with one another and with the soil, atmosphere, and sunlight in the complex network of relationships that constitute an ecosystem.

Think of a forest as an example. A forest is more than an assemblage of trees. Living in the shade of trees are shrubs, vines, herbs, ferns, mosses, and toadstools. Dependent upon these plants and living among them are insects, birds, mammals, reptiles, and amphibians. The animals depend on plants for food, shelter, and other needs. The plants use sunlight, carbon dioxide, water, and minerals to make food that sustains themselves and other organisms in the forest.

Process-Oriented Concepts. By defining and emphasizing specific concepts, SCIIS permits teachers and pupils to concentrate on the objectives of the program. Five process-oriented concepts—*property* (or characteristic), *variable, system, reference object,* and *scientific theory*—underlie and are essential for development of competency in the processes of observing, describing, comparing, classifying, measuring, interpreting evidence, predicting, and experimenting.

Property. We have already referred to the properties by which an object may be described or recognized. A property is any quality that enables you to describe, compare, or classify objects. Color, size, shape, texture, and scent are properties of a blossoming plant; color, density, and hardness are properties of a mineral specimen; and size, color, and style are properties of a suit of clothes.

Properties also enable you to describe concepts. For example, duration is a property of a time interval; accuracy is a property of a carefully-made measurement; and the term climate (hot, cold, temperate) summarizes the properties of weather in a specific region.

Variable. Properties and conditions that differ from one experiment to another are important in scientific

work, and they have been given a special name—variables. Examples are the temperature of water being warmed by the sun, the amount of fertilizer added to a potted ivy plant, the length of time a flashlight battery has been used, and the number of crickets feeding on a particular patch of grass.

System. System is a word that has entered everyone's vocabulary. We deal with the nervous system, communications systems, electronic systems, and systems analysis. In all of these a system is a whole made up of related parts. Earth and its moon form a system of two closely interacting bodies in space. A seed, moist soil in which it is planted, and air form a system. The system concept reflects the fact that objects and organisms do not function in isolation but exist in a context of interaction with other objects or organisms.

When one system is part of another system, it is called a *subsystem.* The earth, including its atmosphere, plants, and animals, is a subsystem of the earth-moon system. The seed, with its embryo, seed coat, and stored food, is a subsystem of the seed-soil-air system.

The terms object, subsystem, and system allow us to use three levels for grouping the elements that attract our attention in an event. We shall use the word "object" for individual pieces of matter, "subsystem" for intermediate groups of objects, and "system" for the largest collection under consideration.

We have concentrated on "closed" systems in the SCIIS physical/earth science sequence. A closed system is defined by the matter of which it is composed. Whenever matter is added to, removed from, or replaced by, other matter, the original system becomes a new system. When nothing is added or removed, a system retains its identity even though it may change in form or appearance.

Sometimes (especially in the life sciences) scientists find it useful to work with "open" systems, which are defined by the matter occupying a certain region of space. The air space within a terrarium is an example. In an open system there may be changes of matter without changes in identity—as when water vapor, carbon dioxide, and oxygen enter and leave the air even though the terrarium is covered. The ecosystems children investigate in Level 6 are examples of open systems. Children who continue to study science may learn to distinguish between open and closed systems when that distinction becomes important.

Reference object. The fourth process-oriented concept, reference object, helps children overcome the limitations of describing position and motion only from their own point of view. Space exploration has shown that we can no longer think exclusively in terms of up-down and north-south as defined on the earth. For young children—who at first relate objects only to themselves—the use of external reference objects is a challenge.

In SCIIS, the basic concept is simple: Position and motion of objects can be described only with reference to other objects, including (possibly) the body of the observer. When you say, "Meet me at the north end of the picnic area," you describe the location of the meeting place relative to the picnic area. In the example, the picnic area serves as reference object and the compass direction serves as reference direction. When you say, "The main entrance to the museum is to your left," you are using the listener's body as reference object.

The child who can take into account several reference objects and reference directions overcomes a spatially self-centered viewpoint. The concept of the earth as a sphere in space can be understood only in relation to a reference object not located on the earth itself; therefore an understanding of reference objects is fundamental to further work in earth and space sciences.

Scientific theory. An example of a scientific theory is the ray theory of light, which holds that light consists of rays propagating from a lamp or other light source to your eye or an illuminated object.

An everyday example of theory-building can be derived from a look at a common pay phone. How does the coin turn on the phone connection? One might imagine that the coin falls on and depresses a small platform, thereby closing a switch. What is your theory of how the coin turns on the telephone? Keep in mind that many phones work with a dime but not with a nickel, or with two dimes but not with three nickels, even though a nickel is heavier than a dime.

Scientific theories provide explanations for natural phenomena such as light, photosynthesis, weather, heredity, chemical combination, or the solar system. A theory usually postulates certain unseen relationships or objects, such as light rays emanating from a lamp, the platform in a telephone, or atoms in a material substance. Theories also lead to predictions and new discoveries about the events being investigated. If the predictions are not borne out, a theory may be discarded. By using scientific theories, children can relate present observations to previous and subsequent experiences with similar events.

Structure and Content

The SCIIS program consists of thirteen learning units in science for children at preschool, kindergarten, and elementary school levels. The introductory unit, *Beginnings*, leads into two six-unit sequences—the physical/earth science sequence and the life/earth science sequence.

The two sequences are complementary in that either of the two units for any one level may be used first. For example, at Level 1 you may use *Material Objects* in the fall and *Organisms* in the spring, or vice versa. This flexibility permits switching of units between two classes at midyear. (Supplementary and alternate packages of materials are available for schools wishing to switch units, to share unit kits among two or more classes, or to supply exceptionally small or large classes.)

The physical/earth science sequence guides children through carefully selected investigations of the physical world. In the same way, the life/earth science sequence focuses attention on the biological world. Both sequences include treatment of some topics relating to the earth sciences—shadow astronomy, map coordinates, water and mineral cycles, and climatic factors are examples.

SYNOPSES OF THE UNITS

Concepts and processes developed and emphasized throughout the SCIIS program have been described in the preceding "Conceptual Framework." The following summaries list the concepts and processes most important within each unit.

Level K *Beginnings*
Concepts and processes emphasized in this unit: color, shape, texture, odor, sound, size, quantity, position, organism.

The *Beginnings* unit for kindergarten and early childhood education offers a wide variety of activities and experiences in both life and physical sciences. Most of the activities are designed for use in small-group learning situations. Children learn to observe, discriminate, and describe, using objects and organisms in the classroom and outdoors. These early experiences help them develop language and participation skills and contribute to their growing understanding of science. The *Beginnings* unit leads into the physical/earth science and life/earth science sequences.

SCIIS STRUCTURE AND SEQUENCE OF UNITS

K — BEGINNINGS

	Physical/Earth Science Sequence	Life/Earth Science Sequence
1	MATERIAL OBJECTS	ORGANISMS
2	INTERACTION AND SYSTEMS	LIFE CYCLES
3	SUBSYSTEMS AND VARIABLES	POPULATIONS
4	RELATIVE POSITION AND MOTION	ENVIRONMENTS
5	ENERGY SOURCES	COMMUNITIES
6	SCIENTIFIC THEORIES	ECOSYSTEMS

Physical/Earth Science Sequence

Level 1 *Material Objects*

Concepts and processes emphasized in this unit: object, property, material, serial ordering, evidence.

The children handle, observe, and describe objects. They learn that objects are composed of materials and have properties by which the objects can be discriminated; that some objects are solids, while others are liquids or gases; that objects can change; and that there are ways to recognize evidence of change. Property comparison leads to the concept of serial ordering. As the children investigate the properties of various materials, they realize that the same substance can exist in more than one form, and they gain an awareness of the principle of conservation of matter.

Level 2 *Interaction and Systems*

Concepts and processes emphasized in this unit: interaction, system, evidence of interaction, interaction at a distance.

The concept of interaction is introduced, as well as the concept that related objects or parts comprise a system. Students examine a variety of interactions, some of which are directly observable, others less apparent. The evidence that an interaction has taken place comes from the observed change in the system. The children investigate gear/pulley systems, chemical systems, magnetic systems, and electric circuits to observe and interpret evidence of interaction.

Level 3 *Subsystems and Variables*

Concepts and processes emphasized in this unit: subsystem, solution, evaporation, histogram, and variable.

The subsystem concept is introduced to give the children a grouping of objects intermediate between a single object and an entire system. The children's work with solid and liquid materials extends their understanding of the subsystem concept. They learn that filtering will separate an undissolved solid from a liquid, but that solids dissolved in solutions must be identified by the residue that remains after the liquid evaporates. Histograms are used to record and interpret data collected by the students. The variable concept helps them to identify and investigate factors influencing their experiments.

Level 4 *Relative Position and Motion*

Concepts and processes emphasized in this unit: reference object, relative position, relative motion, polar coordinates, rectangular coordinates.

The ideas and techniques developed in this unit are related to concepts of earth and space science. Students find that descriptions of position and motion are meaningful only if reference to objects and coordinate systems—both polar and rectangular—are included in the descriptions. An artificial observer, Mr. O, serves the children as an introductory reference object. They see that reference to different objects and coordinate systems leads to different descriptions of position and motion. Children also learn to use a variety of reference frames to describe both the position and the motion of objects in their everyday environment.

Level 5 *Energy Sources*

Concepts and processes emphasized in this unit: energy source, energy receiver, energy transfer, energy chain.

The concepts of energy source, energy transfer, and energy receiver constitute the core of the unit and are illustrated with experiments exploring mechanical and thermal systems. The importance of solar energy to meet some of our needs is emphasized in this unit. The children's descriptions of the amounts of energy transferred from a source to a receiver help to prepare them for understanding and applying the principle of conservation of energy.

Level 6 *Scientific Theories*

Concepts and processes emphasized in this unit: scientific theory, color, magnetic field, electricity, light ray.

The extended investigations and formulation of scientific theories in this unit conclude the physical/earth science sequence. In *Scientific Theories,* children create their own theories to explain their observations of colored light, magnetic interactions, electric circuits, and simple ray optics. Investigations provide opportunities for students to think of theories to explain the operation of systems of interacting objects and to devise tests to distinguish among alternate proposals. In doing so, they gain a deeper understanding of how scientists work.

Life/Earth Science Sequence

Level 1 *Organisms*

Concepts and processes emphasized in this unit: organism, birth, death, habitat, food chain, decay.

The stage is set for the unit as children plant seeds, watch the growth of the seedlings, and experiment to see how external conditions affect growth. Their observations are extended to a model ecosystem—an aquarium. They observe changes that occur in the aquarium, including the growth of plants and animals, animals feeding on plants, animals eating other animals, birth, death, and decay. Experiences with classroom plants and aquariums give children a general introduction to the overall theme of the life/earth science units: the interaction of organisms with their environments.

Level 2 *Life Cycles*
Concepts and processes emphasized in this unit: growth, development, life cycle, genetic identity, plant and animal, metamorphosis.

Attention is shifted from the ecosystem as a whole to some of its important parts—individual plants and animals. Through experiences with living, dead, and nonliving objects, the children have an opportunity to learn these classifications of objects around them. Living and dead organisms are further subdivided into plants and animals. By observing live, growing, developing, reproducing plants and animals, the children become aware of the fact that living objects have life cycles.

Level 3 *Populations*
Concepts and processes emphasized in this unit: population, plant-eater, food web, biotic potential, animal-eater, plant-animal-eater, predator-prey.

The children learn that the individual plants and animals they observed in previous units live as groups in nature. They build, maintain, and observe terrariums and aquariums, and they investigate the interactions of populations—food webs, for example—in each system. The concept of biotic potential can be inferred after the pupils are asked to imagine, with the help of prepared charts, what could happen in a population if reproduction continued without any deaths.

Level 4 *Environments*
Concepts and processes emphasized in this unit: environment, environmental factors, biotic, abiotic, range, optimum.

The environment of an organism consists of biotic factors, which include all the other plants and animals living in the same area; it also includes abiotic factors, such as light, temperature, air, water, and soil. The children experiment with both plants and animals to discover the effects of changing various factors, to establish a range of conditions for testing each factor, and to find the optimum part of a range for each organism. On the basis of data collected from these experiments, students build terrariums with suitable environments for the organisms. They discuss and plan a human environment that includes other organisms on which humans depend.

Level 5 *Communities*
Concepts and processes emphasized in this unit: pyramid of numbers, raw materials, reproduction, community, producers, consumers, decomposers, photosynthesis, food transfer, competitors.

In *Communities*, emphasis is placed upon interactions among different populations of organisms, the most important of which concerns food. Students examine the interdependent relationships among plants (as producers), animals (as consumers), and microorganisms (as decomposers). The children investigate the capacity of green plants to produce food. They build terrariums containing plants, crickets, and salamanders, and observe the food-chain relationships. And they observe the results of decomposition after burying dead crickets in moist sand.

Level 6 *Ecosystems*
Concepts and processes emphasized in this unit: ecosystem, water cycle, oxygen-carbon dioxide cycle, pollution, food-mineral cycle.

The cycle concept is introduced by means of experiments with evaporation and condensation of water that lead to an understanding of the water cycle. Students learn that the ecosystem is maintained by the intake of energy from the sun and by the continuous recycling of materials between organisms and the environment that surrounds them. Ecosystems are seen to include all the concepts in the life/earth science sequence as children see the pattern of ecosystems in North America and identify their own ecosystem. Changes in the balance in natural ecosystems, including those caused by pollution, are studied.

Helping Children Learn with SCIIS

SCIIS is a science program based on direct experience. It is intended to affect the ways children think and reason. In addition it is expected to influence how they will reason and make decisions about problems when they become teenagers and adults. Such thinking and decision-making may well determine the individual's responses to a wide variety of personal and societal issues: Should I smoke or not? Should I vote for or against the use of coal as an energy source in my community? In both cases the intelligent person must be able to understand the variables, critically assess advertising campaigns and the statements of special interest groups, and separate emotional appeals from real evidence.

SCIIS fosters this kind of thinking and decision-making, which is quite different from the kind of skill-oriented learning that takes up a large part of the child's elementary school experience.

The need for skill learning. Children need to learn the skill aspects of language, writing, and arithmetic. Your role in teaching these skills is that of an instructor (one who imparts information) who knows precisely what is to be learned and "gets it across" effectively. The importance of such instruction cannot be questioned, because the skills are basic to participation in society.

Development of reasoning. The individual, however, deserves and needs a great deal more than skill learning to participate meaningfully in a democratic society. The ability to use one's own experiences as a foundation for understanding, interpretation, and decision-making in life is essential. It is this ability to observe, collect evidence, analyze, and use the information obtained from one's experiences that is emphasized in the SCIIS program.

For these reasons your role when teaching such experience-based science is that of a helper and fellow-investigator, rather than only that of an authority or imparter of knowledge. The sections that follow describe the components and organization of SCIIS, and how you can use the program to help children learn both science and the approach to decision-making inherent in science.

PROGRAM COMPONENTS

Teacher's Guide. Central to each unit of the SCIIS program is the Teacher's Guide. It shows how the unit is broken into parts and chapters. Specific learning objectives are listed at the beginning of each Part. The rationale underlying the Part is explained under the heading "Background Information." Next is an "Overview" of the chapters that make up the Part. Any suggestions for organizing time and equipment are provided in notes titled "Planning Ahead" and "Getting Ready."

Each chapter begins with a color panel containing a chapter synopsis, the time suggested for covering the chapter, and a list of materials needed for the activities. Major headings within a chapter are "Advance Preparation," "Teaching Suggestions," "Optional Activities," and "Extending Your Experience (EYE) cards." If background information specific to the chapter is needed, it is included just before "Advance Preparation."

At the end of each Part, notices tell you which EYE cards (in the kit) may now be made available to the children and refer you to the appropriate evaluation activity at the back of the Guide.

Following the last chapter of the Guide you will find an "Evaluation" section, a glossary of important terms, and a page explaining design and use of the equipment and materials kit. The life/earth science units also contain an appendix on care of organisms (following the glossary) and an overall schedule of activities.

Scheduling. One activity may extend beyond a single science session, or several activities may be included in one session. The "Suggested time" for working through a chapter is *only* a suggestion; adapt your schedule to allow for special student interest or for greater use of a chapter or activity that is particularly appropriate in your locale.

Teaching suggestions. Under this heading you will find all the activities intended for use by the whole class. Most activities are carried out by individuals or teams working with the necessary materials to collect data or other evidence. While this happens, you are free to move around the classroom to help those who have problems.

Once the data are collected, conduct a discussion of the results, and encourage children to draw conclusions about the data. The work with the equipment and materials and the subsequent discussions are fundamental to the reasoning and decision-making processes SCIIS is designed to foster.

A willingness to improvise and depart from the teaching suggestions will better enable you to meet your pupils' needs. Students may ask questions not anticipated in the Guide or that do not lead in the direction you planned. When this happens, permit the pleasure of a "side trip" by encouraging interested individuals or small groups to investigate independently and report back to the class.

Optional activities. In many chapters individual and small-group needs and interests are met by the "Optional Activities" section. These expand upon topics brought up in the chapter or help in reviewing concepts studied earlier. You may use optional activities to:

- extend the main activities if a child raises a related question
- emphasize one topic for the entire class
- expand the unit extensively if your class is more mature than usual for this level

Optional activities make use of materials provided in the program, common household supplies, or other readily available items. We hope you will include at least a few of these activities in your program, but we do not expect you to use all of them.

Evaluation and feedback. Feedback is information that comes to a person in response to something the person did. As a teacher, you are collecting feedback from your pupils most of the time. An answer to a question yields feedback. So does a child who looks out the window during your demonstration. Informal feedback is an important way to evaluate the progress of your class. In this Guide, we will try to alert you to feedback situations in which children's responses are likely to influence your teaching plans.

In addition to the feedback suggestions included in each chapter, we have prepared an evaluation section that uses a more formal approach to evaluating your students' learning. In general, there is one evaluation activity for each Part of the unit.

Teacher's glossary. Scientific terms and concepts used in the unit are defined in the glossary. The definitions are appropriate for reference during discussions or review and are not intended to be technically exhaustive. We do *not* recommend that you use the glossary to have children memorize formal definitions of terms and concepts.

Equipment and materials kit. Each SCIIS kit includes all necessary materials for the unit except live organisms, common items such as pencils and paper, and perishable items such as batteries.

Each chapter in the Teacher's Guide begins with a list of materials needed and their location in the kit. Starred (*) items in the list are to be provided by the teacher. "Design and Use of the Kit" (page 94) and labels on each kit drawer also indicate placement of items.

Live organisms. The life/earth science units require that you order shipments of live organisms (already paid for), prepare suitable habitats, and allow time for growth and development of the organisms. The life/earth science kits contain the forms for ordering SCIIS organisms. At the back of the Guide, the "SCIIS Plants and Animals" appendix and the "Schedule of Activities" will help you plan and carry out all work with live organisms.

Student manual. The student manual has two major functions: It helps guide the children through their experiences with the equipment and materials, and it provides a place for the individual to record observations, findings, or measurements. During many activities the children record information about experiments in their manuals. This may provide the basis for later discussions.

Encourage children to make entries independently, even though their reports may disagree with those of classmates or with what you consider to be "correct." Some children may change their responses; let them cross out the first entry and add the new one. In this way, their original record is preserved and may be compared with later observations. Records in the manual should be informative, but they need not be perfect.

In addition to organizing the children's work and record-keeping, the manual contains some problems to be solved either individually or in class discussion. But most of the manual is directly related to the children's experiences with the equipment and materials. This relationship makes the SCIIS student manual different from the typical elementary "workbook."

Collect the manuals periodically to review the children's record-keeping and problem-solving abilities. We suggest you refrain from writing in the manuals, either to commend or to correct mistakes. If you find repeated errors in reasoning or data interpretation, arrange for a conference with the child.

Extending Your Experience cards. These cards (two duplicate sets with a display box) are provided primarily to encourage development of individual interests. We have controlled vocabulary on the cards, so that most children should be able to read them unassisted. The illustrations are intended to help the children work independently. Make each card available — by adding it to those in the display box — at the time its use is recommended in the Guide.

The cards may be used in a variety of ways, ranging from totally independent work to a more controlled situation in which you or an aide suggest and supervise a pupil's use of a card.

Some cards may be used for review or remedial purposes. Some may be assigned to provide additional experiences for children new to the SCIIS program. The cards to be used with review chapters at the beginning of the Guide will prove useful for these purposes.

Encourage children to report orally, in writing, or through picture displays after they complete work with a card. They can report to you, to their team, or

to the class as a whole. In this way, children can benefit from the opportunities for language development inherent in the use of the cards.

As children express interest in topics not covered by the cards provided, you might help them develop new cards that relate to their specific interests.

THE LEARNER IN SCIIS

The SCIIS program is intended for children between the ages of 5 and 12–13 years. Therefore, the teaching approach needs to be matched to the learning styles, interests, and capabilities of children of these ages. Research on the learning of young children has led us to recognize a three-stage development in the way children learn. These stages are explained more fully in the following sections.

Exploration. Children learn about something through their own spontaneous handling and experimenting with objects to see what happens. Thus in SCIIS children first explore materials with minimal guidance in the form of instruction or specific questions. The materials have been carefully chosen to provide a background for certain questions the children have not asked before.

You can help exploratory activity by asking questions and making comments that encourage further involvement. An individual's creative use of materials can be pointed out as a means of providing others with new ideas. During exploration activities you have the opportunity to observe the children and draw conclusions about their existing ideas and understandings. This evaluation can be the basis for further planning and instruction.

Invention. Spontaneous learning is limited by preconceptions. After exploration, a child needs new concepts to interpret observations. Since few children can phrase new concepts by themselves, you will have to provide definitions and terms as new concepts arise. This constitutes the "invention."

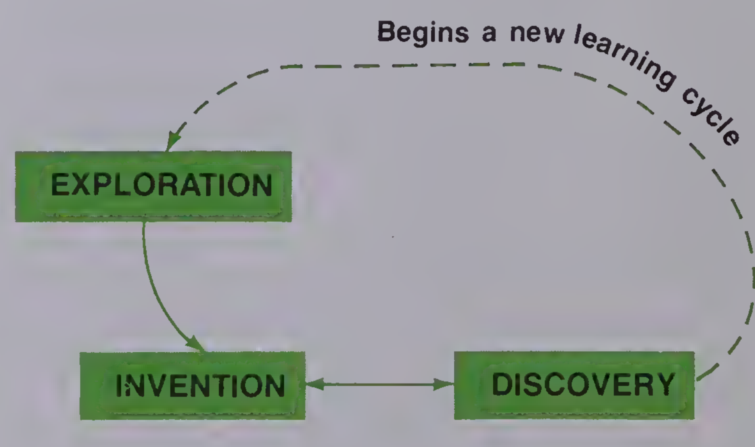
During an invention lesson, be clear and explicit when you give a definition, repeating it several times if necessary. To give the children opportunities to use a concept, encourage them to look for examples that illustrate the new idea. When they report such examples — immediately or during later discovery activities — you gain feedback about their understanding of the concept.

Keep in mind that the "invention" or introduction of a new concept is just the start of an experiential process for a child. Knowledge, understanding, and eventual ability to use the concept in daily life will come from experiences the child has during and after the discovery activities.

Discovery. We use "discovery" to describe those activities in which a child finds a new application of a concept through experience. You may plan a variety of situations leading to discovery, or you may depend on a child's own experiences to furnish these applications. Discovery activities strengthen the original concept and enlarge its meaning. Mastery and retention of concepts are aided by practice and repeated application in the variety of situations provided in the activities.

During discovery sessions, your role is to assist the children so they can effectively work with materials and see how concepts apply. In this stage they are actively involved, and you can spend your time with individuals or small groups to observe their work and to ask questions that spur further investigation. Where necessary, reintroduce the concept previously explained or review earlier ones.

The learning cycle. Exploration/invention/discovery are stages in a learning *cycle* because each stage can always lead to another. Exploratory sessions frequently include discovery activities for prior concepts while creating a need for your introduction of the new concept. Invention sessions frequently lead to questions best answered by giving children opportunities to work on their own, and thus to discover applications of the new concept. Discovery activities can provide opportunities to reintroduce concepts "invented" earlier and they can permit children to explore the next concept. Diagrammatically we can represent the learning cycle this way—



The Learning Cycle

At the beginning of the "Teaching Suggestions" for each chapter we have indicated the stage(s) of the learning cycle emphasized in the activities that follow.

Implementing learning stages. Exploration, invention, and discovery can be implemented with varying degrees of direction. A more structured approach is illustrated when an entire session is used for introduction of a concept in a presentation to the whole

class. This should be preceded by exploratory activities and followed by discovery activities of a more personalized nature.

Using a less formal technique, you may introduce a new concept to individual children during their exploratory or discovery activities. To do so, join one child or a small group and use the child's own equipment to illustrate the concept. This method may be used effectively during the review chapters at the beginning of each unit after Level 1. Regardless of the approach you choose, you may have to explain and illustrate a new concept repeatedly to individual children during discovery activities.

TEACHING APPROACHES AND STRATEGIES

Organizing the classroom. Teachers who have contributed to the development of the SCIIS program have found that many responsibilities for preparation and cleanup can be shared by pupils. The following suggestions will help your class enjoy successful laboratory sessions:

1. In many SCIIS activities, children work in small teams — usually pairs. Plan teams carefully, to insure maximum cooperation.
2. For ease in managing supplies and cleanup, assign two or three teams to a work area — a table, or several desks of equal height pushed together. Such a group can share one water container, one waste pail, soil, and other shareable items. They also can exchange ideas about the activity. One member of each group may serve as a laboratory aide.
3. Ask your aides to assemble supplies for each team or group and to help you in passing out equipment. Or you can have them assist you in placing sets of equipment at distribution stations around the room. You may want to post signs at stations to identify equipment and indicate how much is to be used by each team.
4. Invite parents or other community members to assist you as aides in the class. Invite individuals with scientific backgrounds or interests to present special activities relating to activities under way, or to supervise a team working on a special project.

Discussions. Conversation among children or between teacher and children is an important part of the learning process. While participating in experiments, children spontaneously exchange observations and ideas with one another. During an invention session, you illustrate and explain a new concept. When gathering feedback, you may address a question to a particular child.

On other occasions, we suggest discussions in which the children report on their experimental results, compare observations, and sometimes challenge one another's findings. Many children should participate in these discussions, and you, the teacher, should avoid controlling the topic or the pace. Encourage the children to comment to one another, without calling on specific individuals to recite in turn. Grouping them to face one another around an open area promotes exchanges.

If you call attention to disagreement between two findings, you invite evaluative comments and suggestions — which may lead to further meaningful discovery activities. Announcing that one child is right and another one wrong rarely leads to further discovery experiences. Instead, such action encourages children to ask you, as the authority figure, for the answers; it reduces their commitment to independent investigation — which is fundamental to an understanding of science.

Asking questions. The questions you ask and the way in which you ask them will affect the children's work and attitudes. Note the difference between "What did we study yesterday?" and "What did you find out yesterday?" Though both questions call for review of a previous activity, the former only seeks an answer already in the teacher's mind. The latter inquires into a child's own experience.

A question that aims for a predetermined answer is often called *convergent* because of its specific goal. Most questions in multiple-choice tests are of this nature (as are many questions asked by some teachers). A question that allows a variety of answers is often called *divergent* because it may lead in many directions. Provocative discussion questions are usually of this nature.

Suit your questions to your purpose. If you wish to gather feedback about understanding or recall of a certain fact, ask a convergent question. Often this is best done individually, perhaps while small-group work is in progress. When you are looking for a specific answer, make this clear to the child.

If you wish to spark discussion ask a divergent question, and then sit back while several children propose answers. If the children continue their discussion without your leadership, so much the better.

Language development. During extensive use in urban, rural, and suburban schools, the earlier SCIS program proved to be particularly helpful in improving children's oral language skills. Experience with the program was especially effective in the case of disadvantaged children, whose desire to participate in class discussions increased greatly.

In SCIIS we have increased the suggestions and ac-

tivities especially designed to encourage oral and written language development. The addition of Extending Your Experience cards, for example, encourages language development, since the child is asked to describe orally, write about, or prepare a display about the results of the activity.

Mathematics development. The SCIIS program can also do much to encourage children's development of mathematical concepts and processes. Children are urged at all levels to consider the quantitative aspects of their observations and activities. For example, in the *Material Objects* unit (Level 1) the child's concept of number is reinforced by having the child select a specific number of objects as indicated by a numeral card you display. Later, in *Subsystems and Variables* (Level 3) and *Environments* (Level 4) the use of quantitative measurements to produce histograms and graphs is emphasized. Such use of quantitative data provides opportunities for reviewing mathematical concepts, processes, and skills. For many children the introduction to histograms and graphing will be their first experience with these powerful mathematical tools.

Children new to the program. The great appeal of SCIIS derives from its reliance on direct experience, and most children will learn quickly how to participate effectively. However, a few may have difficulty because they lack background or are not accustomed to working independently. You can take several steps to make the transition easier for them.

First, all units after Level 1 begin with a review. By supplementing the review with appropriate activities and EYE cards from previous units, you can help children become familiar with concepts introduced earlier in the program. Use these activities individually or with groups.

Second, you can help a child gain confidence in independent work by showing him or her that there are often a number of alternate acceptable procedures and results in an activity. Encourage the children to find various ways to use pieces of equipment, commend their ideas, and let them share their findings with others.

Populations: An Overview

In the first chapter, which provides a review of some major ideas in *Organisms* and *Life Cycles,* the children are reintroduced to the concepts of plant, animal, organism, growth, and development. This prepares the class for studying populations of organisms, both outdoors and in the classroom.

Seeing isolated groups of daphnias and aphids increase and decrease in number, children learn to relate increases to reproduction, declines to death. On the basis of this experience the population concept is "invented" during the Part One activities. The children next observe daphnias moving from one area to another. You then introduce the concepts of *dispersal* and *barrier*.

In Part Two the concept of biotic potential of populations is inferred after the pupils imagine, with the help of prepared charts, what could happen to the number of daphnias or bean plants in a population if reproduction continued without any deaths.

Several populations live together in terrariums and aquariums that the children build in Parts Three and Four. The terrariums contain grass, clover, mustard, aphids, crickets, and chameleons. In the aquariums there are populations of daphnias, damselfly nymphs, snails, algae, and *Wolffia*.

By observing the interacting populations in the terrariums and aquariums, your pupils gain some understanding of food relationships among populations in nature. For example, the children observe crickets eating grass and mustard, and chameleons eating the crickets. Thus the grass and mustard populations are reduced, and the cricket population is eventually eliminated. In the aquariums the damselfly nymphs eat daphnias, and daphnias eat algae. When the children cannot discover the feeding relationships in the terrariums and aquariums by direct observation, they set up experiments to determine them.

After the class sees animals eating plants and other animals, the terms plant-eater and animal-eater are introduced. The same situations provide examples of predators and prey. Feeding relationships among plants, plant-eaters, and animal-eaters are identified as food chains and food webs.

Concepts. The children's experiences with terrariums and aquariums in *Populations* continue the study of ecology begun in *Organisms* and *Life Cycles* and serve as a background for these important biological concepts:

- **population**
- **plant-eater**
- **food web**
- **biotic potential**
- **animal-eater**
- **plant-animal-eater**
- **predator-prey**

Lesser concepts introduced in this unit are: dispersal and barrier.

Part One

RAND McNALLY
SCIIS

Populations

OBJECTIVES

To use the term "population" to refer to a group of organisms of one kind living and reproducing in a particular area.

To predict that production of offspring may result in an increase in population size.

To predict that when the population becomes too large for the area, individuals may die or disperse.

To predict that death of organisms may result in a decrease in population size.

BACKGROUND INFORMATION

An organism—any plant or animal—is rarely found living alone. Organisms live in groups of their own kind, or species. The group in any one area is called a population. Population size refers to the number of organisms in the group, not the physical size of the individuals.

Populations of different kinds of organisms live together, interact in various ways, and usually are dependent on each other. One of the major dependencies is based on food. Populations of plants produce food. Some animal populations eat plants, other animal populations eat the plant-eaters. And still other animals eat both plants and animals.

Individual plants and animals in a population are eaten or die of other causes, but the population size is maintained through reproduction. Normally more offspring are born than can survive in a given area, and many of these move away. When individuals move away from the area occupied by their population, we call this "dispersal." Animals disperse using normal methods of locomotion. Plants are dispersed when their seeds are carried away by the wind, by water, or by animals.

Sometimes dispersed organisms are eaten or succumb to adverse environmental conditions. In that case the only advantage of dispersal to the species is that individuals of the original population, which is now small, have more space and food. But if a new population becomes established, the species has a greater chance for survival if environmental conditions change.

Objects or conditions that prevent the dispersal of individuals are called barriers. For example, bodies of water are barriers to the dispersal of terrestrial organisms, and dry land is a barrier to the dispersal of aquatic plant and animals. Mountains are barriers for animals that cannot walk or fly over them and for plants whose seeds cannot be carried over.

Figure I-1. Dandelion seed dispersal.

OVERVIEW

In Chapter 1, "Review," your students observe developing brine shrimp eggs and clover seeds in fresh and salt water. The concepts of organism, plant, animal, growth, and development are reviewed. Children plant seeds in Chapter 2, "Planting Peas and Beans," to have growing plants as food for aphids in Chapter 5.

In Chapter 3, "Organisms Around the School," the class takes a field trip to obtain organisms living in the vicinity. (*Note:* If inclement weather prevents you from taking the children outdoors, omit or postpone Chapter 3.)

In Chapter 4, "Daphnias," and Chapter 5, " 'Inventing' the Population Concept," your pupils count and record the numbers of daphnias and aphids for two or three weeks or until there is a marked change in the counts. On the basis of the classroom records showing increase or decrease in the number of organisms, the population concept is "invented." The terms *dispersal* and *barrier* are introduced following the children's observations of the behavior of aphids. This is followed by observation of dispersal of daphnias in Chapter 6, "Dispersal." In Chapter 7, "What Caused the Population Decrease?" the students set up experiments to determine possible answers to the question.

GETTING READY

You must order the organisms in Live Organisms Shipment P-1 at least three weeks before you begin Chapter 4. You will need algae and daphnias for Chapter 4 and aphids for Chapter 5. (See "Schedule of Activities," page 96.) When you mail the order form, record on your calendar the arrival date you requested.

At least two days before you plan to teach Chapter 1, wash a 6-liter container (do not use any cleaning compounds) and fill it with tap water. (When tap water is "aged," or exposed to air for forty-eight hours, the chlorine content is reduced below the level that is harmful to organisms.)

Two days before you start Chapter 4, age more water in four fluted containers. Each container should be three-quarters full.

Before doing any work in the classroom with living organisms, be sure to read "SCIIS Plants and Animals," pages 86-93.

1 Review

SYNOPSIS

Children place brine shrimp eggs and clover seeds in fresh water and salt water to see in which they will grow.

Their observations lead to review of concepts from previous units: **animal, plant, organism, growth,** *and* **development.**

Suggested time: ***three sessions***

TEACHING MATERIALS

For each child:

Drawer 1

student manual pages 2 and 3

For each team of four children:

Drawer 2

4 vials with caps
2 magnifiers

Drawer 3

4 labels
2 twistems
2 medicine droppers

For the class:

1 stirring stick*

Drawer 2

9 vials

Drawer 3

1 plastic tumbler
1 twistem

Drawer 4

2 six-liter containers

Drawer 5

1 package of clover seeds

Drawer 6

1 vial of brine shrimp eggs
1 package of noniodized salt

* provided by the teacher

BACKGROUND INFORMATION

Brine shrimp are tiny marine animals, commonly used for fish food. Their eggs will remain viable even though dried and stored for long periods.

Eggs placed in a solution of noniodized salt will hatch within twenty-four to forty-eight hours. The hatched brine shrimp are orange and extremely small, but you can easily see them by using a magnifier.

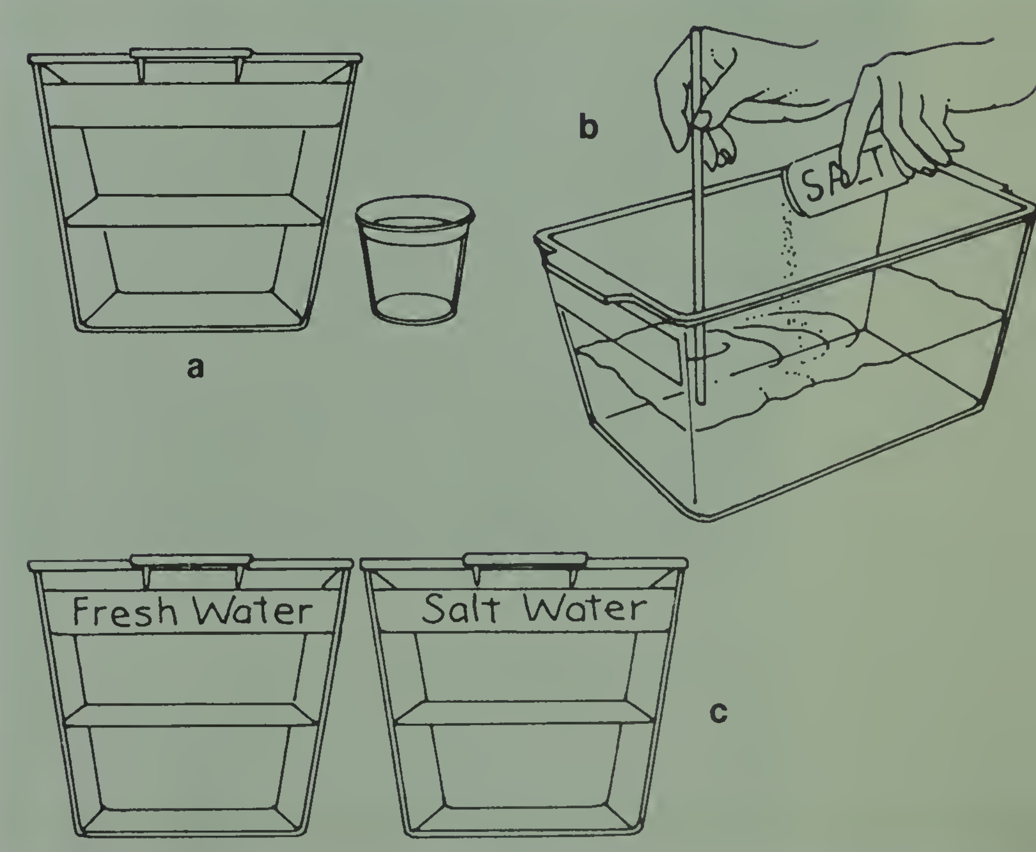
In most classrooms, the brine shrimp will live from four to six days.

ADVANCE PREPARATION

Using aged tap water, prepare the salt solution as follows:

- Set an empty 6-liter container and a tumbler side by side on a level surface.
- Pour aged tap water into the 6-liter container until the water level is as high as the tumbler rim.
- Pour the entire package of salt into the measured water and stir with the stirring stick until the salt crystals have dissolved.
- Pour an equal amount of aged tap water into a second 6-liter container.
- Label the two containers "salt water" and "fresh water."

Figure 1-1. Preparing saltwater and freshwater setups.



Pour the brine shrimp eggs into four vials and the clover seeds into four other vials. (Do not label the vials or show the children the labels on the original containers.) Set up four distribution stations for seeds, eggs, vials and caps, labels, twistems, and magnifiers. Place the water containers near the distribution stations.

Figure 1-2. Equipment and organisms can be distributed quickly and with minimum confusion if they are set out at several stations.

TEACHING SUGGESTIONS

The lessons contained in this chapter are discovery lessons. The children apply past experience to identify brine shrimp as animals, clover as plants, and both as organisms; and they observe growth and development in these new organisms.

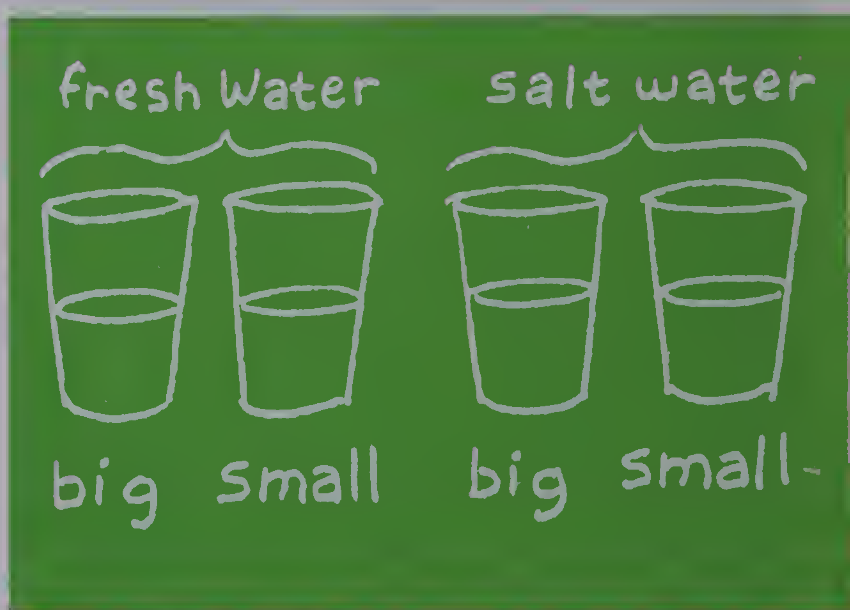
Planning experiments. Divide the class into eight teams. Ask one member of each team to get two magnifiers from a distribution station. Demonstrate how to use the magnifier by holding it close to one eye while moving the object to be observed back and forth until it comes into focus.

- Hold up a vial of each kind of organism and tell the children you have eggs and seeds for them to observe. Do not identify which are eggs and which are seeds.
- Put a few brine shrimp in a vial cap, and some clover seeds in another, for each team.
- Suggest that the class observe the organisms for a few minutes to see how they differ.
- The children may wish to name the two kinds of organism to distinguish between them. (One cass named them "fats" and "skinnies." Encourage your own pupils to select their own names.)
- After the pupils have observed the seeds and eggs, tell them that one organism lives in salt water and the other lives in fresh water. Point out the equipment and ask them how they could determine in which kind of water each lives.
- As the pupils suggest experiments, write or draw their ideas on the chalkboard to help them design their experiment.

Children at this age level need assistance in planning experiments. Our trial teachers have found it helpful to draw sketches of the experimental setup on the chalkboard as a child describes it, modifying the sketch as the experimental design is improved.

If seeds and eggs are placed together in salt water, brine shrimp development is inhibited. For this reason, discourage a plan that includes placing both kinds of organisms in the same vial. A diagram of the experimental design might resemble the one illustrated in Figure 1-3.

Figure 1-3. One class's experimental design.



Setting up experiments. Eggs and seeds can be removed from the supply vials with a bent twistem.

- Show the class how to bend twistems as illustrated in Figure 1-4. Demonstrate how to use the "measurer" by dipping the bent tip into the vial of organisms, lifting it straight up, and lowering the organisms into an empty vial.
- Have each team obtain four vials with caps, four labels, and two twistems. The children should half-fill 2 vials with fresh water and 2 vials with salt water by dipping them into the water containers.
- Team members should list their initials, the type of water, and "fats" or "skinnies" (or some other designation) on the labels, and put the labels on the vials. Have the children add the two kinds of organisms to the appropriate vials, cap the vials, and store them out of direct sunlight.

Observing the organisms. After two or three days, have the team members examine the seeds and eggs. There will probably be great excitement when the children discover that the "skinnies" are now tiny, orange, moving objects and the "fats" are green plantlike objects. Allow time for observation; then gather your pupils for a discussion.

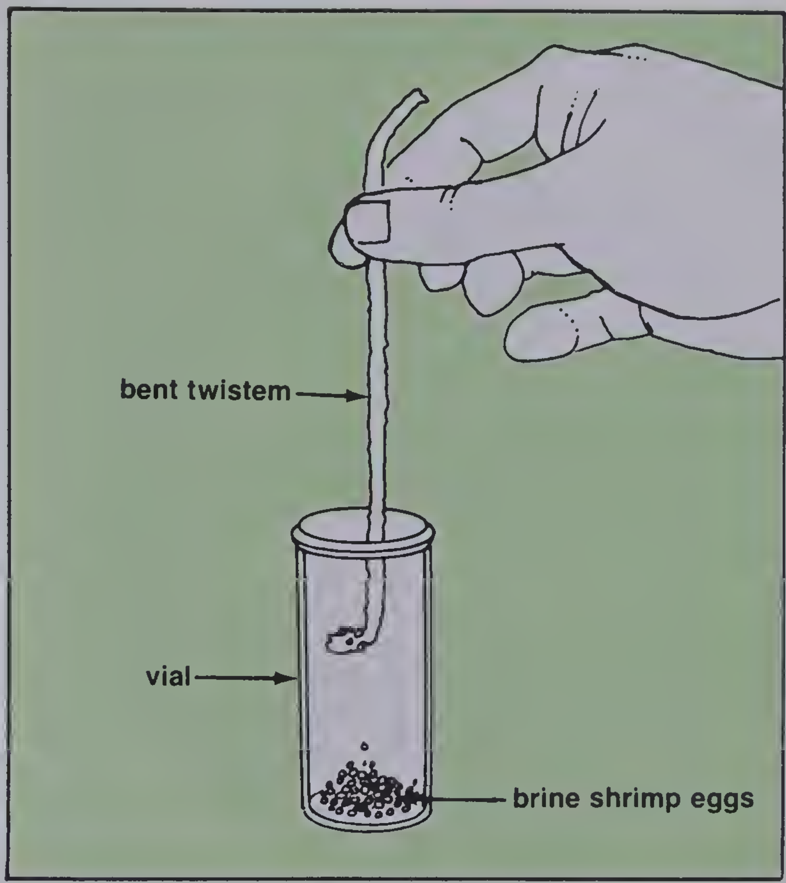


Figure 1-4. The end of a twistem is bent so that a 3 mm (1/8 in) scoop is formed.

Figure 1-5. Suggest that the children use medicine droppers to remove organisms from the vials and squirt them into the vial caps, where they can be seen more easily.

Figure 1-6. Clover *(left)* and brine shrimp *(right)*.

Reviewing *plant* and *animal*. Ask the children for their observations and make two lists on the chalkboard—one list for the "fats" and another for the "skinnies."

Now ask them which list of observations describes an animal. Write "animal" above this list and ask how you should label the other list. If no one volunteers "plant," tell the class that those properties describe a plant.

Encourage the students to describe the differences between plants and animals. Most children at this age say that plants have roots, leaves, and stems; and that animals can move by themselves from place to place.

Tell them that the animals are brine shrimp and the plants are clover.

Reviewing *organisms*. Write the word "Organisms" and center it above the words "Plant" and "Animal." Remind the children that organisms are any living plants and animals. To determine if they understand the terms organisms, plants, and animals, name several different plants, animals, and plant-animal combinations, such as apple trees (plants); people (animals); or horses and grass (organisms).

Using student manual page 2. Remind the children to write their names on the manual covers. Have them follow the instructions on page 2 to review *plant, animal,* and *organism*.

Reviewing *growth* and *development*. On another day have each team get its vials, magnifiers, and medicine droppers and observe the clover and brine shrimp. As you walk among the children, listen for any comments on changes in size and shape of the organisms. Have the children return the vials to the storage area and then sit down for a discussion.

- Remind them, "At the beginning of your experiments you did not know which vials contained eggs and which seeds. Do you know now?"
- Ask, "Have there been any changes in the organisms since your last observation?"

- When a child mentions that the clover and brine shrimp are larger, write the word "growth" on the chalkboard and remind the children that when an organism gets larger it is said to be growing.
- Ask the students if the clover or the brine shrimp have changed in form (as from seed to plant; egg to shrimp) or developed new structures (such as leaves or roots). You may need to remind them of the shapes of the eggs and seeds at the beginning of the experiment.
- Remind the children that when an organism gets a new part, that is called "development." Those children who have used the *Life Cycles* unit will probably remember the development of legs on tadpoles or of new leaves on plants.
- Invite your pupils to name some other examples of development, such as caterpillars becoming butterflies, or tomatoes appearing on tomato plants.

Using student manual page 3. The children should be able to indicate that the seed pods are evidence of development.

Cleanup. The children may either transfer their germinated clover plants to soil or discard them. They may continue to observe the brine shrimp as long as they are interested. Afterward, the brine shrimp can be discarded. If you have fish in an aquarium, the brine shrimp can be fed to them. (But don't add the salt water to a freshwater aquarium.)

Because the vials and medicine droppers are used with organisms later, they *must* be washed in clear water to remove all traces of salt.

OPTIONAL ACTIVITY

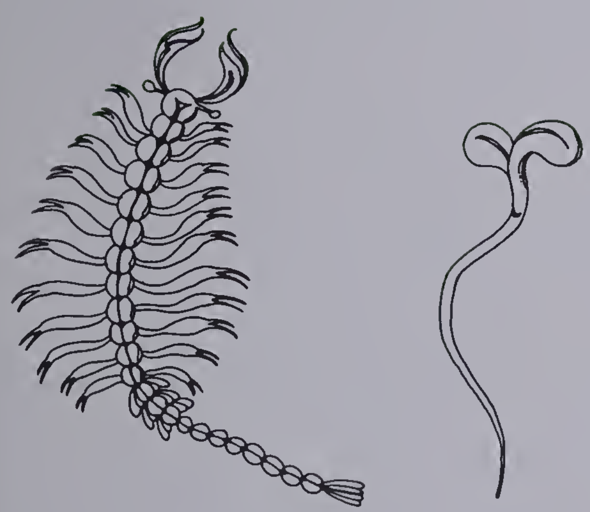
Does the amount of salt matter? Make two dilute salt solutions by placing one teaspoonful of noniodized salt in 5 liters of water, and another teaspoonful in 1 liter of water. Encourage the children to try growing clover in these two solutions, both of which contain less salt than they previously used. Clover seeds should also be grown in a vial of fresh water for comparison with the salt water vials. (The clover will probably not grow in the salt water.)

Chapter 1 3

Write a D under the bean plant that shows development.

What developed on the bean plant? ____________

2 Chapter 1



Draw a line under the animal.

Circle the plant.

What name is used for both plants and animals?

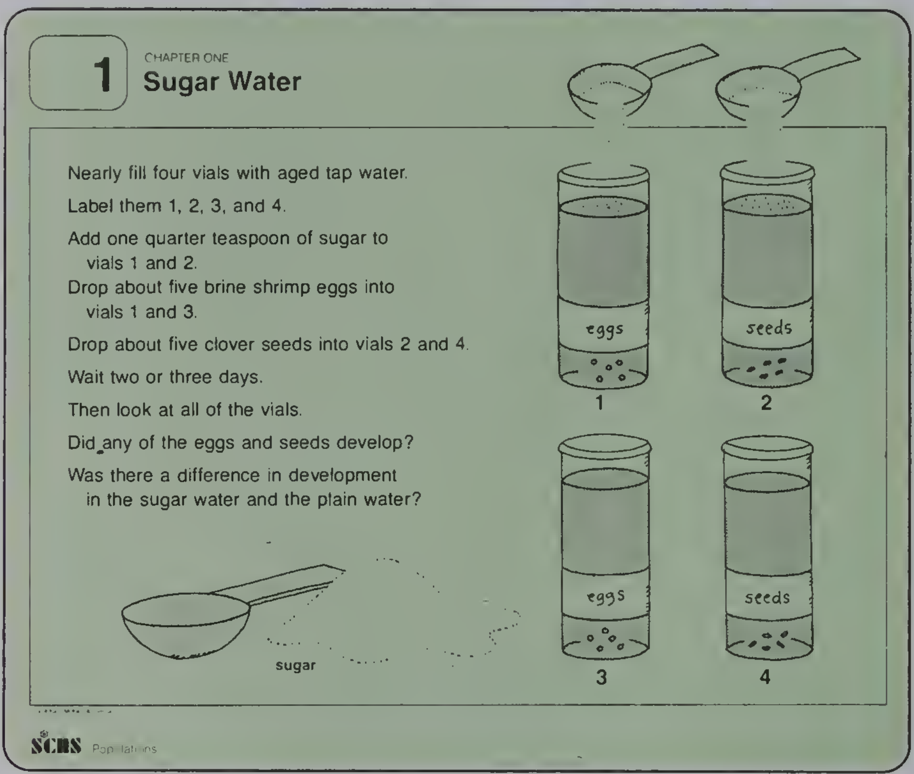
____

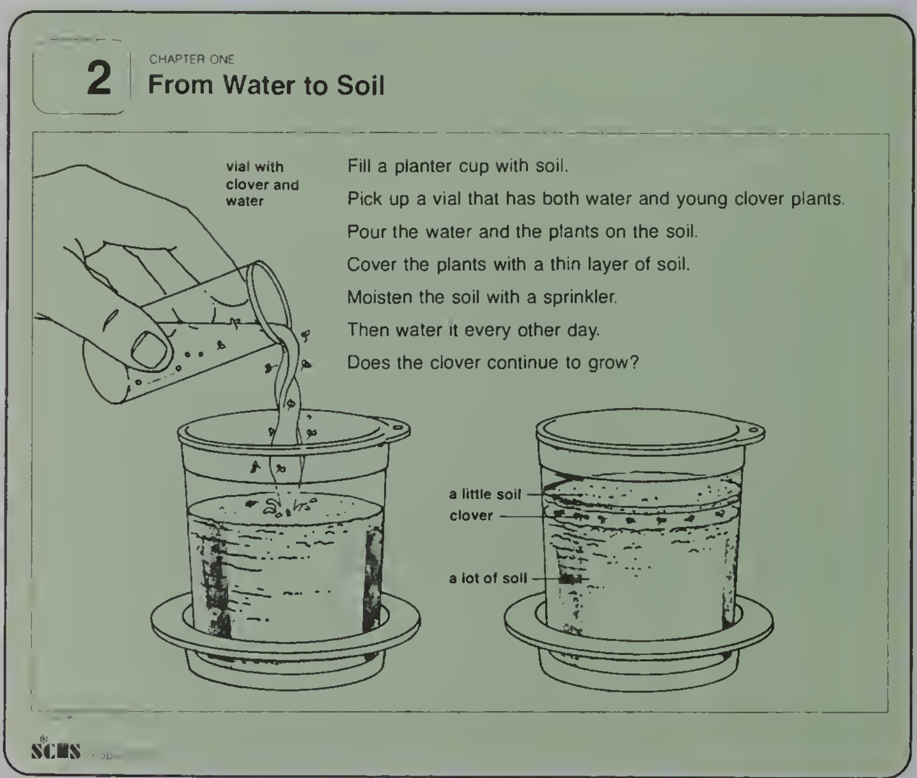
EXTENDING YOUR EXPERIENCE CARDS

For suggestions on using these cards, see page xvii.

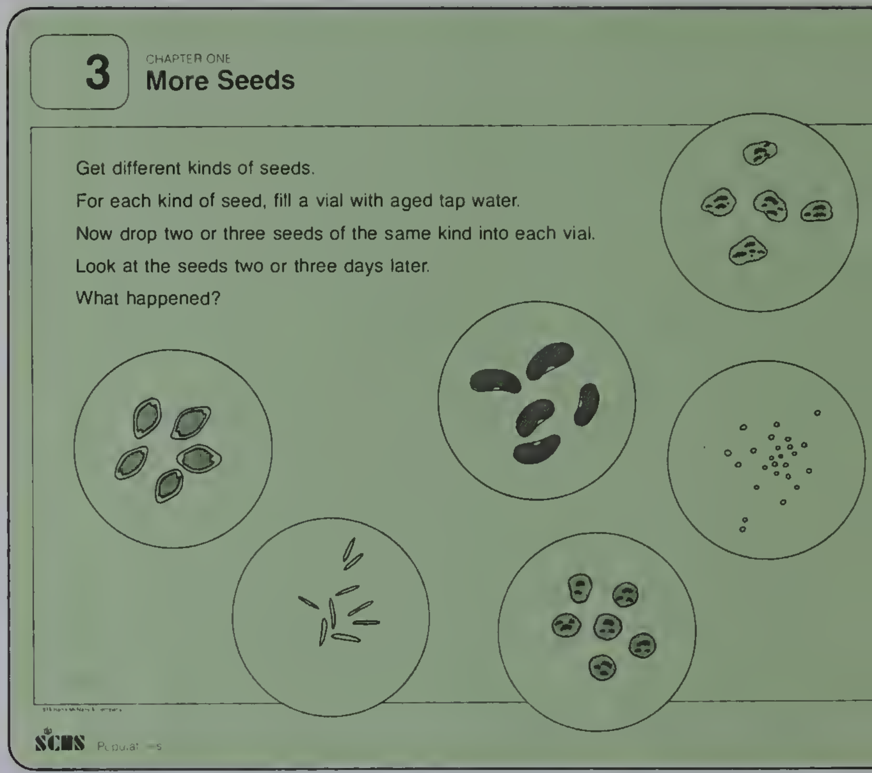
1. Sugar Water. This card should be used only after the students have completed the activity. Eggs, seeds, vials, sugar, and aged tap water are needed.

2. From Water to Soil. This card can be used immediately after the activity, while seedlings are available, or later, when more seeds will have germinated in water. Provide a planter cup, soil, and a vial of clover.





3. More Seeds. Students will benefit most from this activity if they perform it shortly after they observe the germination of clover seeds in water. The seeds pictured are mustard, bean, pea, grass, and squash.



2 Planting Peas and Beans

SYNOPSIS

Children plant pea and bean seeds.

Suggested time: ***one session for planting, followed by short observation periods extending over several weeks***

TEACHING MATERIALS

For each team of two children:

Drawer 3

4 twistems

Drawer 5

3 planter cups
3 planter bases
3 pea seeds
3 bush bean seeds
3 fava bean seeds
3 planter sticks

For the class:

soil‡

Drawer 2

2 light sources
4 trays

Drawer 3

2 plastic tumblers

Drawer 5

4 water sprinklers

‡ in Sand and Soil box

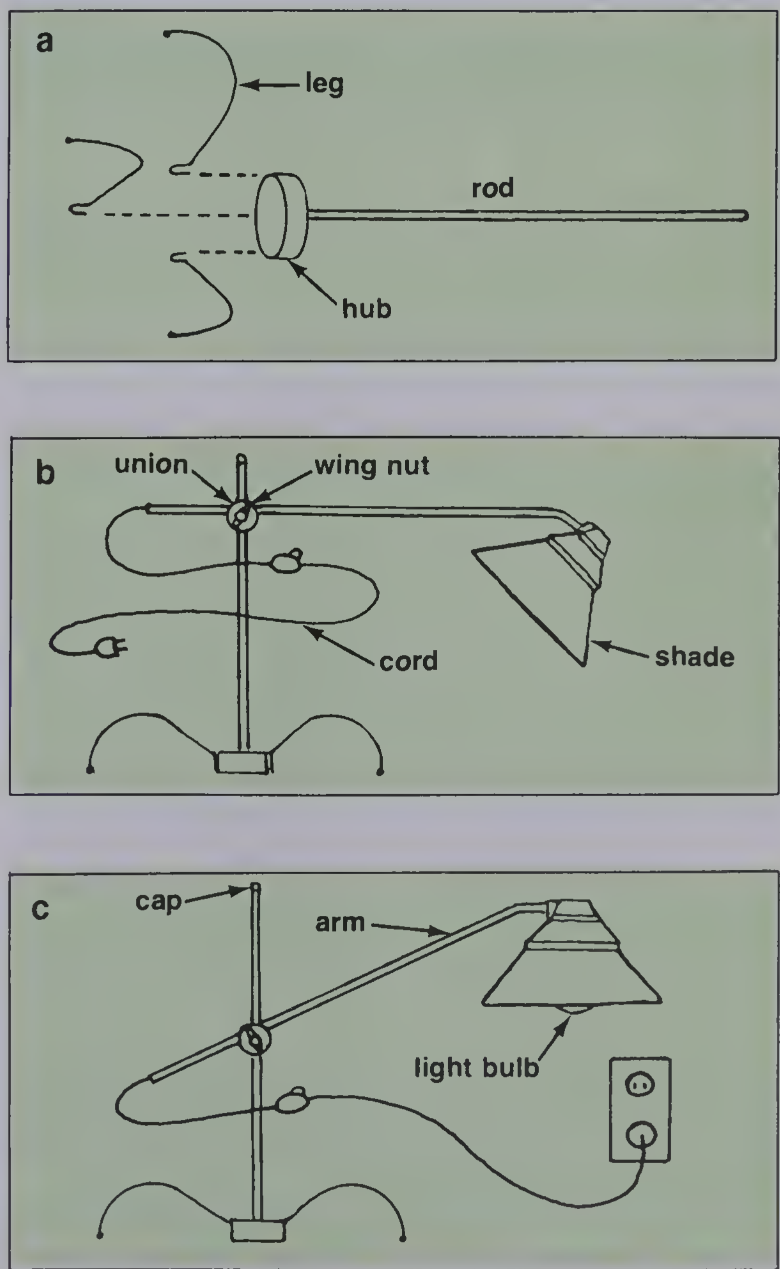
ADVANCE PREPARATION

Set up at least two distribution stations with planter cups, planter bases, seeds (pea, bush bean, and fava bean), and soil at each. Place a tumbler (to be used as a soil scoop) at each station.

Setting up the light source. Take out the three heavy curved wire legs, the center hub, and the support rod, arm, and lamp unit. Then assemble the light source, following the steps in Figure 2–1.

Insert the plug into a wall outlet. You will find that it can only be inserted in one way, because it is polarized for safety. Turn on the switch located in the lamp cord.

Figure 2-1. *(a)* Firmly push the legs into the bottom of the hub. Set this assembly upright. *(b)* Unwind the cord, loosen the wing nut, and push the rod through the union. *(c)* After lowering the union and rotating the arm to the desired position, tighten the wing nut. Keep the bottom of the shade parallel to the table. Cap the rod and add the light bulb.



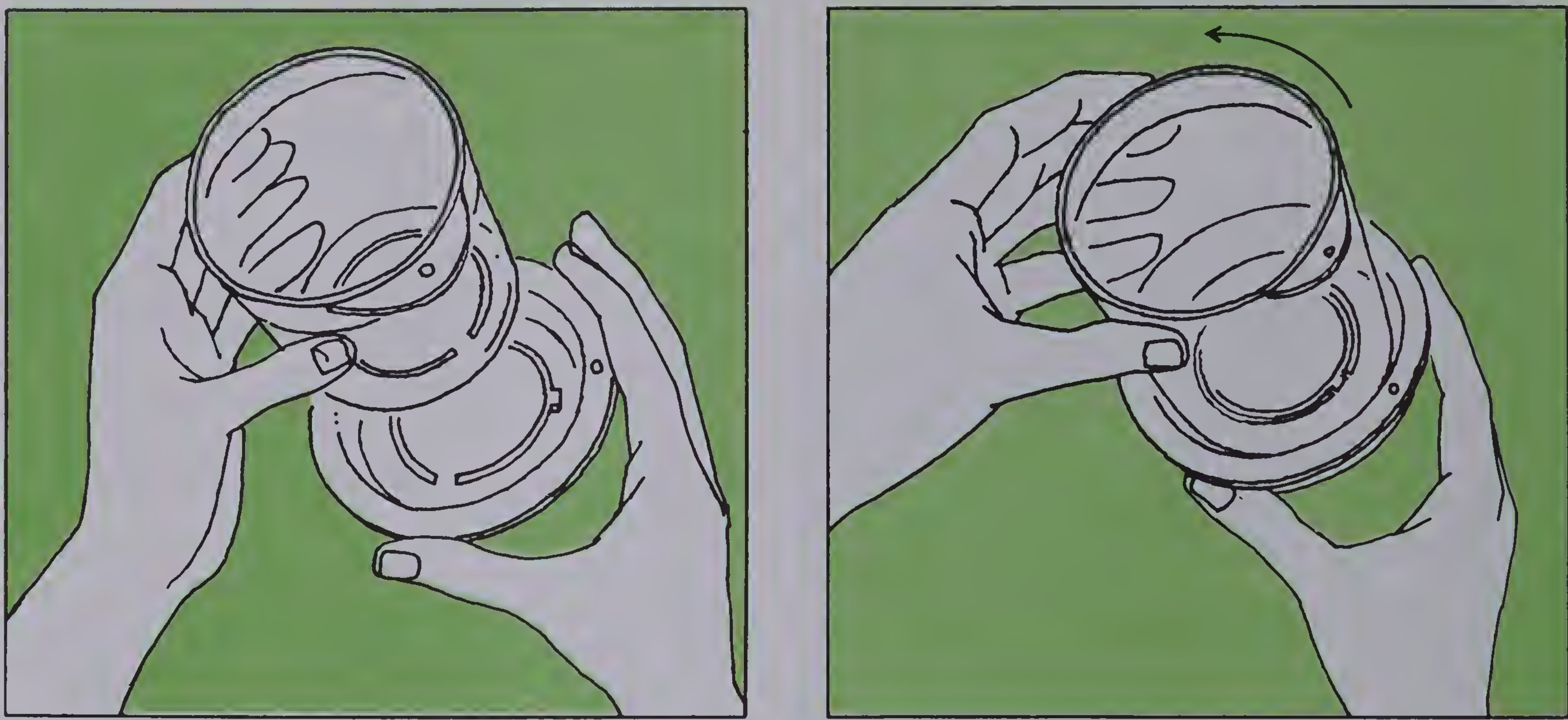


Figure 2-2. Push the planter cup into the base. Turn until you feel the two parts lock together.

TEACHING SUGGESTIONS

The children probably have planted seeds before and have seen what conditions are necessary for plant growth. If so, this is a discovery activity.

Planting seeds. Let each team obtain the necessary materials. Tell the children to fill their planter cups up to the frosted rims with soil and then put the cups and bases together as shown in Figure 2–2.

Show them how to place the seeds 2 or 3 centimeters (1 inch) apart near the center of the cup, push them about a centimeter into the soil, and cover them. Plant pea seeds, bush bean seeds, and fava bean seeds in separate cups.

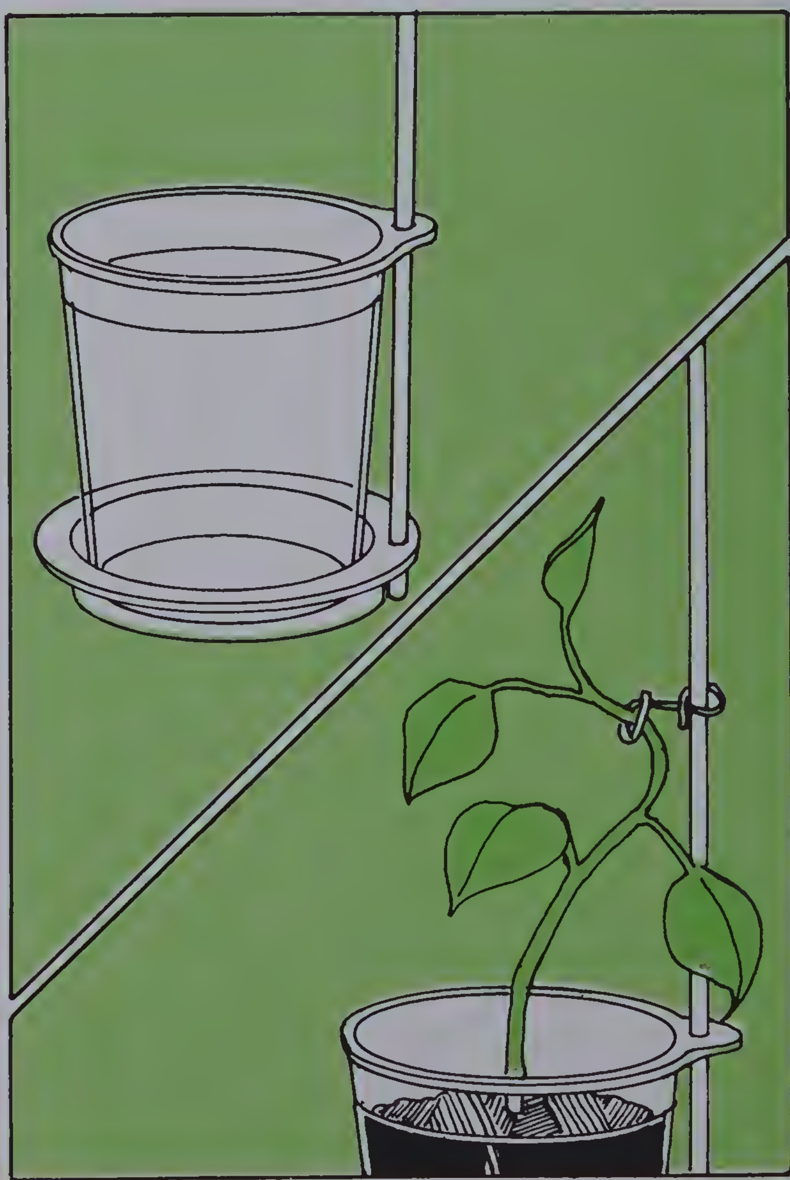
Immediately after they have planted the seeds, the students should write their names, the date, and the kind of seed on the frosted rim of each cup. They should then water the soil using the sprinklers. The soil in the planters should be watered once again the next day to insure fast seed germination, but on following days only when the soil surface is dry to the touch (about three times a week is usually sufficient).

You may wish to prepare a few extra planter cups so that if some of the children's seeds do not germinate, you will have some extra plants for them. If you run short of planter cups, use cottage cheese containers or cut-off milk cartons.

Growing plants. The planter cups should be placed on trays near the light source. When the plants begin to grow above the soil, turn the light on and leave it on at all times, including weekends.

The pea plants and fava bean plants will be used in Chapter 5 to provide food for aphids; the bush bean

Figure 2-3. Push a planter stick through the hole in the planter cup rim and into the hole in the base. Loosely fasten the plant stem to the stick with a twistem.



plants will be used in the activity on biotic potential in Chapter 9, by which time they will have matured and produced flowers and pods.

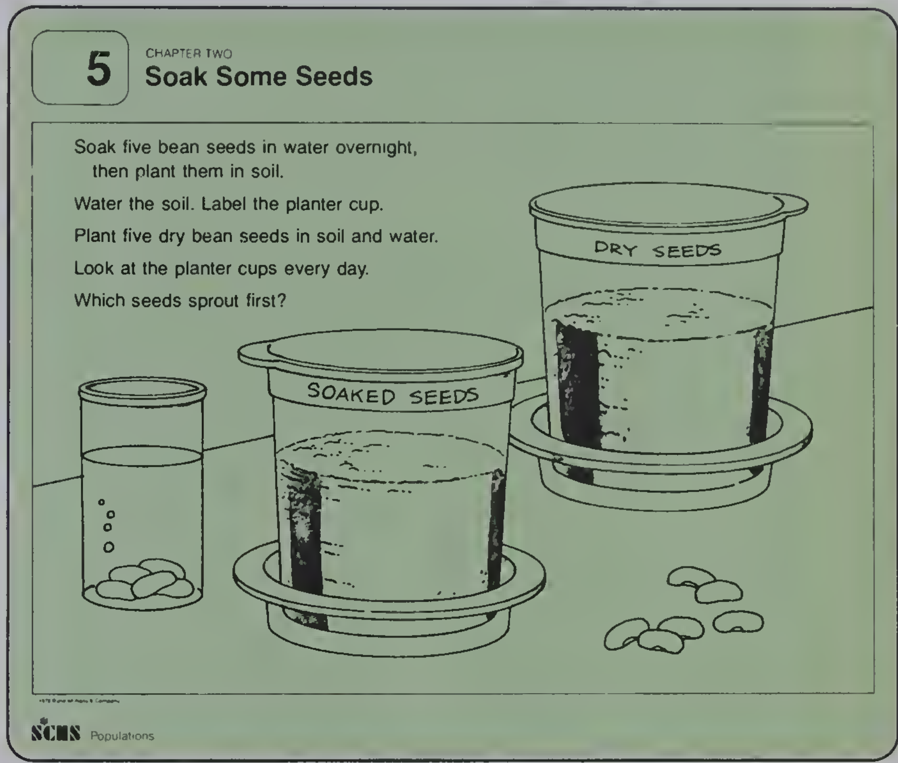
When a plant grows tall enough to need support, help the children attach it to a planter stick, as shown in Figure 2-3. Encourage the children to water their plants every other day and to watch for the appearance of flowers and bean pods.

EXTENDING YOUR EXPERIENCE CARDS

4. Watch a Seed Grow. After the children have seen young pea plants growing in soil, they may be interested in observing the root and stem growing from a seed exposed on a moist paper towel. Two planter cups will be needed.

The white fuzzy stuff growing on the root is made up of root hairs. These aid the root in obtaining water.

5. Soak Some Seeds. This activity works best if used after the students have planted seeds in planter cups and observed the young plants emerging from the soil. A child using this card will need bean seeds, a vial, and two planter cups.



3 Organisms Around the School

SYNOPSIS

The class takes a field trip to observe, identify, and record the numbers of different kinds of plants and animals living in an area near the school.

Suggested time: ***one session***

TEACHING MATERIALS

For each child:

Drawer 3

1 wooden stick

ADVANCE PREPARATION

Select a nearby area where different kinds of plants and snimals live. The area should be small enough so that children can talk with each other easily. We have found that a square or rectangular area of about 50 square meters (about 60 square yards) is satisfactory. Mark the limits of the area so that the children will not go beyond it.

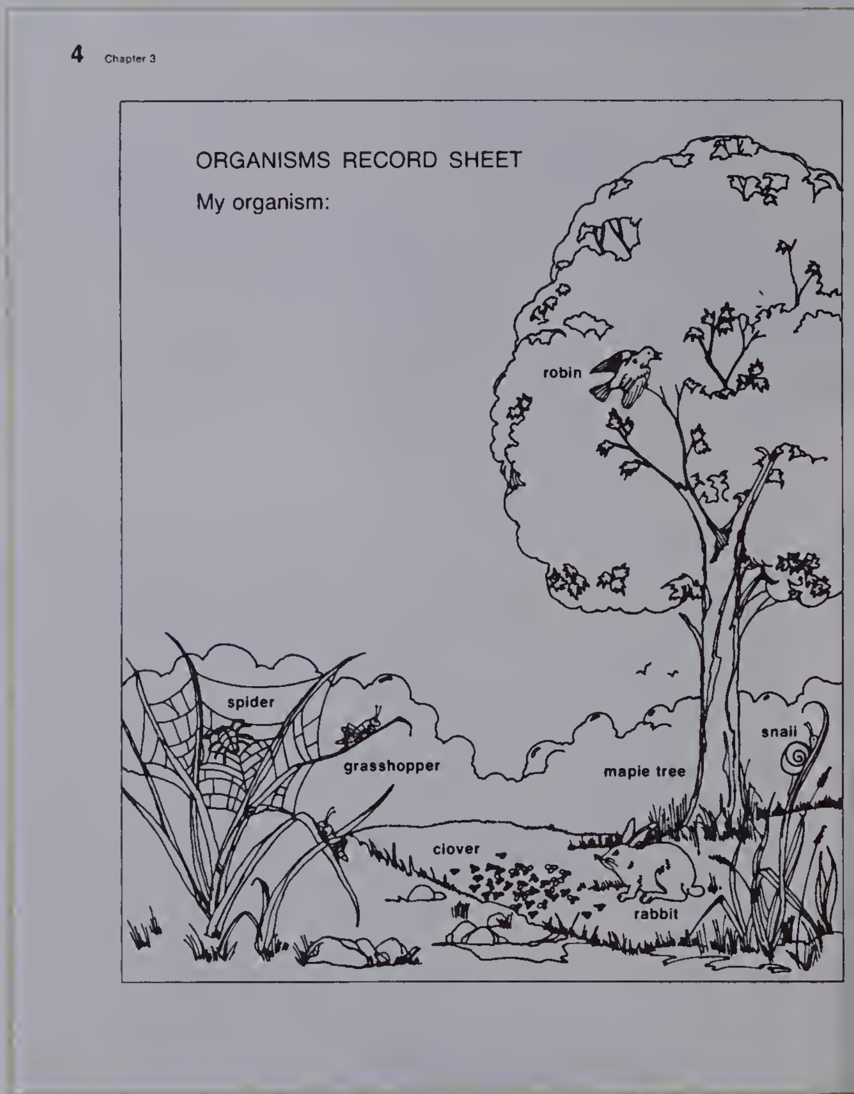
If you cannot take your class on a field trip at this time because of inclement weather, we suggest that you postpone the trip for as little time as necessary. In the meantime, you might show a natural history film on animals in their habitats, or on life cycles.

TEACHING SUGGESTIONS

This is an exploratory activity to give children experience with local populations before introduction of the population concept.

Using student manual page. Tell the students that they will take a field trip to look for organisms and can use the pictures in their student manuals to identify some of the plants and animals they may find.

The field trip. Give a wooden stick to each child and explain that the stick may be used for searching for animals in the soil.


4 Chapter 3

ORGANISMS RECORD SHEET

My organism:

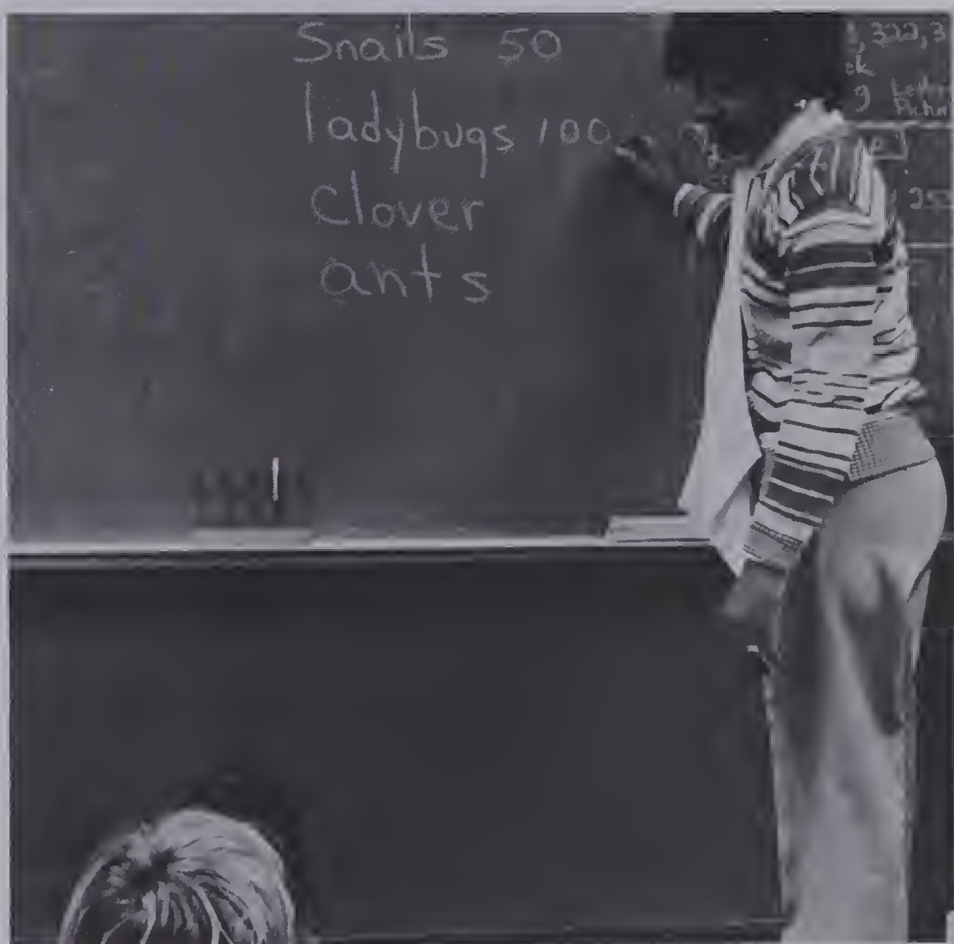
Figure 3-1. Looking for organisms in the soil.

- Tell the children to explore areas without destroying them. Plants should not be uprooted. When an organism is picked up for observation, it should be returned to its original location. Rocks and logs that are turned over should be rolled back into position.
- Take the class outside to the selected area. Point out the boundaries and tell the students that they can search for organisms anywhere within the area.
- Suggest that they identify the plants first and then look for animals on the plants and in the soil.
- Terminate this part of the field trip before the children lose interest in the search.
- If there are many different populations present, help each child estimate the number of organisms of one kind. The organism can be sketched in the space provided in the student manual, and tally marks or a number written under the sketch.
- If there are only a few populations present, or if you are dealing with a very large class, you may want to have the children do the student manual page in teams. This will still give you several population sizes to discuss later. In this case, be sure that the organisms counted include varied kinds of plants and animals.

Discussion. After returning to the classroom, gather the children for a discussion.

- Make separate lists of animals and plants on the chalkboard, recording the number after each organism's name. (The actual numbers are not important; rather, the completed lists should reflect the relative sizes of the populations.)
- According to the lists, which kind of organism is most numerous in the area? Which kind is least numerous?
- Are there more plants or animals?
- Would the children expect to find the same organisms in the area tomorrow? Next week? Next month? In six months? Next year?
- Questions like these will focus the children's attention on real populations in a familiar area.

Figure 3-2. Estimating the total sizes of several populations.



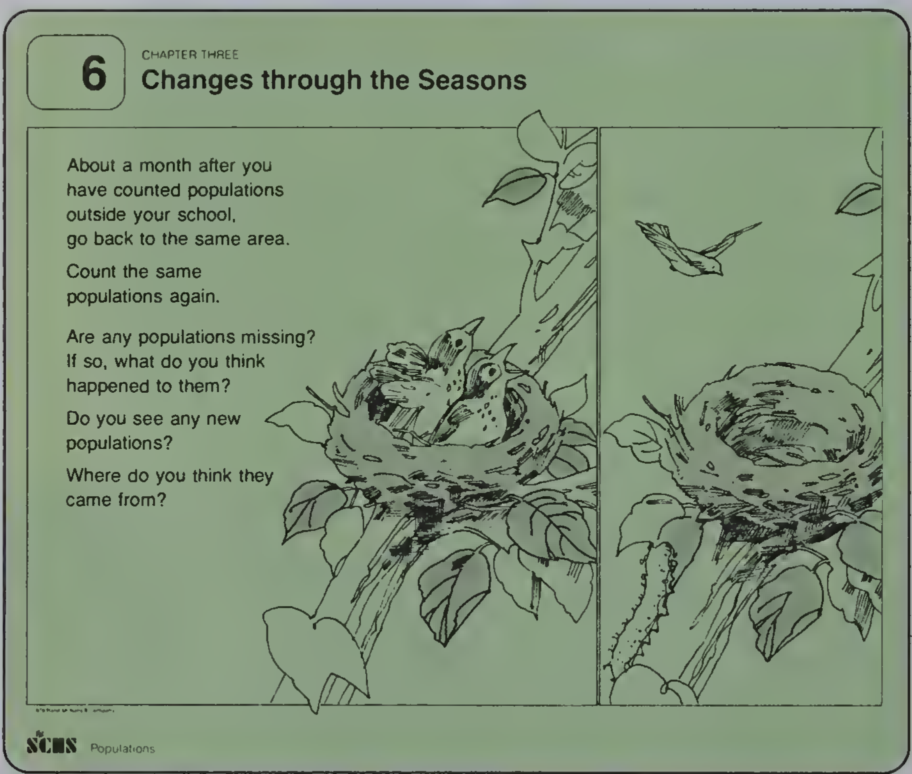
Evidence of life cycles. Did the children observe any seeds, cocoons, or eggs? If so, remind them that the organisms remain in the area from year to year because they produce offspring.

Follow-up. Your pupils may wish to revisit the same area several times during the year to compare the numbers of organisms with their original records.

Population numbers and composition can be charted during various seasons and conditions.

EXTENDING YOUR EXPERIENCE CARDS

6. Changes through the Seasons. Populations of some organisms change in number or may even seem to appear or disappear altogether during certain times of the year. If possible, have students do this activity either during the spring or fall seasons, when the greatest changes usually occur.



4 Daphnias

SYNOPSIS

Students observe daphnias in tumblers of water prior to transferring them to vials.

Children count the daphnias during the next two weeks and record the numbers on a class chart.

Suggested time: *about three weeks. Plan to begin Chapter 5 within a day or two after starting this chapter.*

TEACHING MATERIALS

For each team of two children:

Drawer 2

2 vials
1 vial holder
1 magnifier

Drawer 3

1 plastic tumbler
1 medicine dropper

For the class:

algae†
daphnias†
colored construction paper*
rubber cement*
scissors*

Drawer 1

Daphnia chart
Daphnia graph

Drawer 3

1 plastic tumbler
16 Daphnia counters

Drawer 6

4 fluted containers
1 baster

* provided by the teacher
† in Shipment P-1

ADVANCE PREPARATION

Receiving organisms. Plan to begin this chapter as soon as possible after receiving Shipment P-1, which contains aphids, algae, and daphnias. Remove the covers from the containers of algae and daphnias upon arrival.

Because you will not introduce aphids until Chapter 5, refer immediately to page 91 for information on caring for these organisms.

Preparing cultures. Let your pupils help you carry out the following procedures:

- Divide all the algae water equally among the four fluted containers of aged tap water that you have prepared.
- Pour the contents of the daphnia container through the dip net, discarding the liquid. Then turn the net inside out and dip it into one algae culture to wash the daphnias from the net.

Figure 4-1. Preparing daphnia cultures.

- Label this container "Daphnia culture" and a second container "Algae culture." Place both cultures near the light source.
- About four times per wéek, transfer a basterful of algae water to the "Daphnia culture."

Preparing materials. Using the two remaining containers of algae water, half-fill a plastic tumbler for each team. You may use the baster or simply pour the water into each tumbler.

Use the method shown in Figure 4–2 to transfer daphnias from the culture to the tumblers:

- Scoop the daphnias into the dip net.
- Using the baster, transfer about ten daphnias into each tumbler of algae water.
- Discard any algae water remaining in the fluted containers and refill the containers with tap water. (After forty-eight hours, the water in these containers may be used to maintain water levels in the class daphnia and algae cultures.)

Post the Daphnia chart where all the children can see it. List the children's names in the spaces provided and record the date in the day 0 (zero) column.

Divide the equipment—vials, medicine droppers, magnifiers, and tumblers containing daphnias—among several distribution stations.

TEACHING SUGGESTIONS

This exploratory activity with daphnias provides additional experience with a population before the introduction of the population concept.

Observing daphnias. Have each team obtain a magnifier and a tumbler containing daphnias.

Tell the class that daphnias are small, freshwater animals that normally live in ponds or streams. Many pupils will be familiar with this animal from the *Organisms* unit. They may also recognize that the green color of the water indicates the presence of algae. If

Figure 4-2. Transferring daphnias to a tumbler.

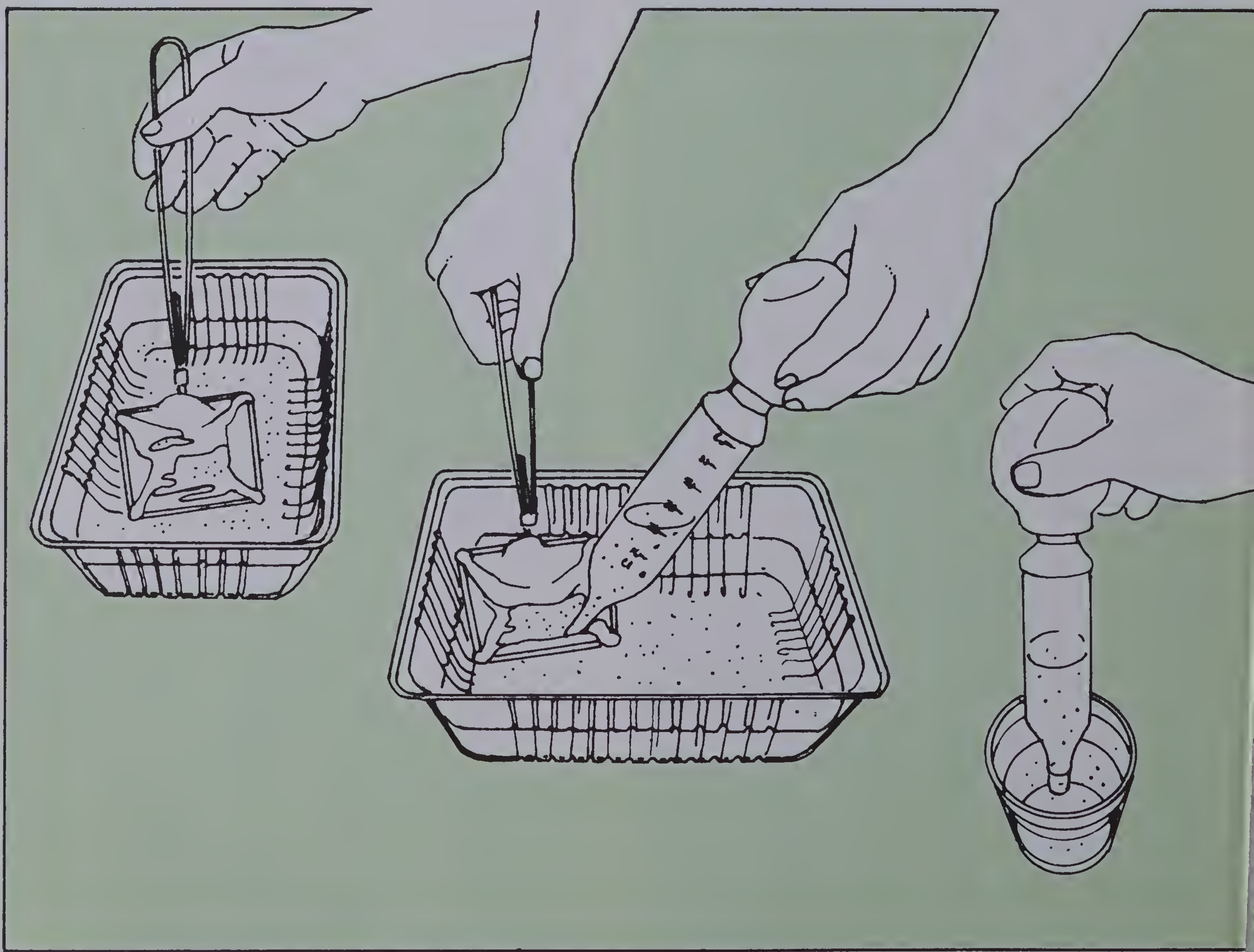


Figure 4-3. Transferring daphnias to a vial.

no one mentions this, explain to the class that algae are tiny plants that live in the same habitat as daphnias.

Give the students time to observe the daphnias with their magnifiers, and then ask your students to describe their observations.

- Some pupils may have observed the green line running through the body of each daphnia. If no one does, point it out and encourage children to look for the line, using their magnifiers.
- Ask, "What do you think that line is?"
- If they do not infer it, tell them that the green material is made up of algae that the daphnias have eaten.

Setting up the experiment. Each team should obtain two vials, one vial holder, and a medicine dropper. The team members should take turns transferring daphnias from their tumbler to the vials. Demonstrate the technique as follows:

- Use the medicine dropper to suck some daphnias from the tumbler.
- Count the number of daphnias in the dropper and squirt them into a vial.
- Repeat this procedure until five daphnias are in the vial.
- With the dropper, add algae water to the vial until it is about three-quarters full.
- Place the vial in the vial holder.
- Repeat the procedure for a second vial.

Caution the children not to add more than five daphnias to each vial. Each child should write his or her name on one vial and place it near, but not under, the light source.

Return any extra daphnias to the class culture. Rinse the tumblers and store them in the kit.

When finished transferring daphnias, each child should record the number of daphnias in that vial in the day 0 column on the class chart.

Tell the children that they will count and record the number of daphnias for about three weeks (until the numbers drop off significantly).

During each counting and recording session, write the number of days elapsed since the start of the experiment at the top of the next available column.

Note: Begin Chapter 5 on the second recording day and conduct the two activities concurrently.

Counting daphnias. Check the vials daily to determine how often you should schedule counting and recording sessions. If the daphnias reproduce rapidly, schedule counts every science period so that the records will indicate a gradual, rather than an abrupt, increase. Counting should continue until the number of daphnias decreases sharply (generally within three weeks).

Counting will become increasingly difficult as the daphnias reproduce. For this reason, small counters have been included in the kit. Demonstrate the technique for using them shown on page 20:

Figure 4-4. Pouring daphnias into a counter.

Figure 4-5. Counting daphnias.

Chapter 4 5

Daphnia counts

Write the date and the number of daphnias in your vial.

Date	Number

Why do you think the number changed?

- Pour a small amount of water from a daphnia vial into a counter.
- Count the number of daphnias present and write this number on a piece of paper. (Let one child on each team count and the other record; they can switch roles with the second vial.)
- Pour the contents of the counter into an empty tumbler.
- Repeat the procedure until all the daphnias have been removed from the vial and counted.
- Record the number of daphnias in the successive counts in a column so that they can be added together later.
- Pour the daphnias and water from the tumbler back into the vial.
- Repeat the entire procedure with the second vial.

Using student manual page 5. Each child should add up the column of numerals to obtain the total number of daphnias in the vial, then record the total in the student manual and in the appropriate column on the class chart. The vials should be replaced in their holders and stored until the next count.

Graphing the number of daphnias. Displaying the data on a graph presents a better idea of the changes in the number of daphnias than recording the data on the chart does. You can use this activity to introduce

Figure 4-6. Returning daphnias to the tumbler.

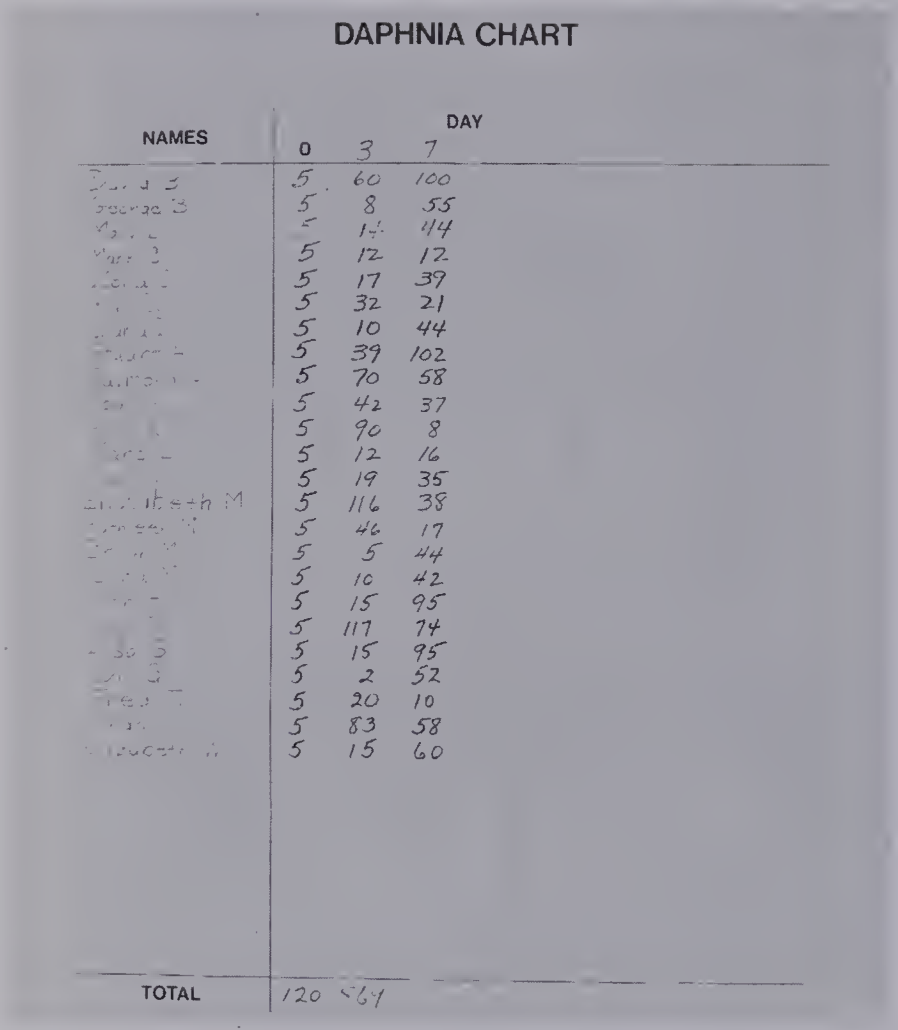


Figure 4-7. One class's Daphnia chart.

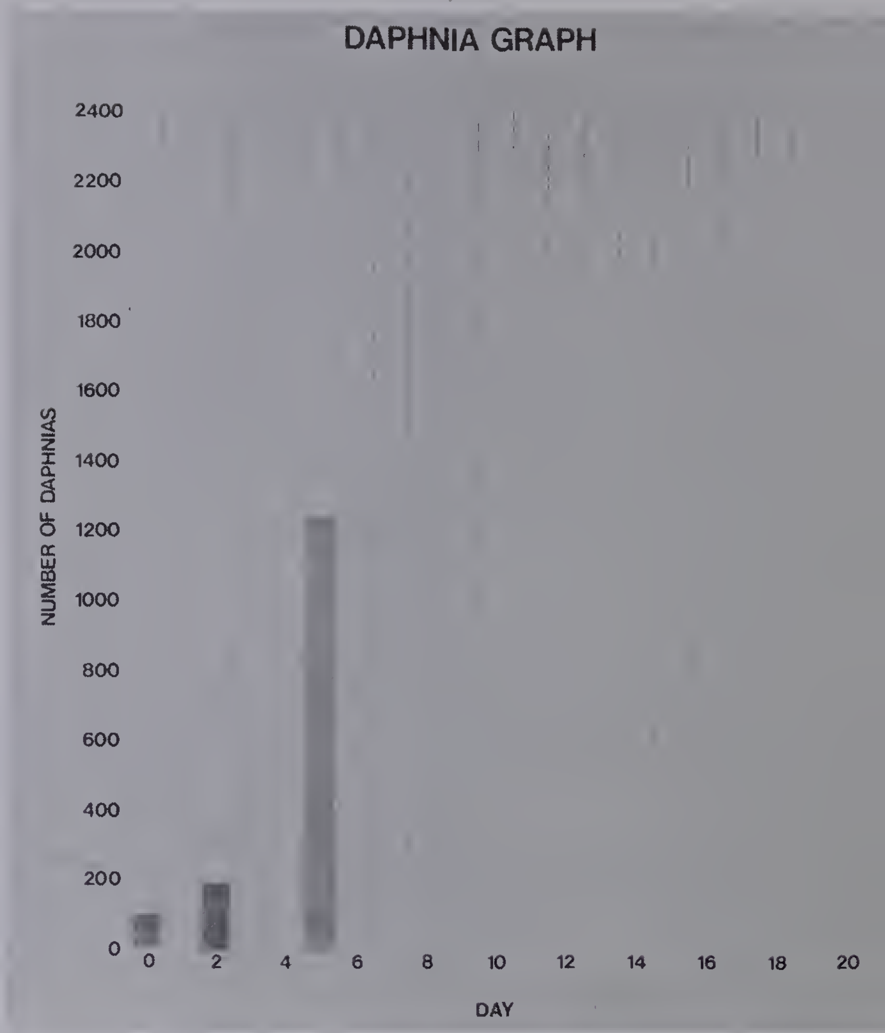


Figure 4-8. A Daphnia graph, showing different data.

the techniques of graph making. Post the graph paper and explain to the pupils that the number of days after the daphnias were transferred to the vials appears "across," or on the horizontal scale, and the number of daphnias appears on the "up and down," or vertical, scale.

Show the class how to transfer the data from the class chart to the graph:

- Add up the number of daphnias recorded on the chart during one counting session.
- Find the numeral on the vertical scale of the graph and measure the distance between that numeral and zero.
- Cut a strip of colored construction paper exactly that length and 25 millimeters (⅞ in) wide.
- Attach this strip to the graph above the column for the appropriate day. (Use rubber cement because you may wish to remove the strips and use the graph again in Chapter 7.)
- Every time the students record on the chart, the class total should be transferred to the graph. You might appoint different teams to transfer data on different days.

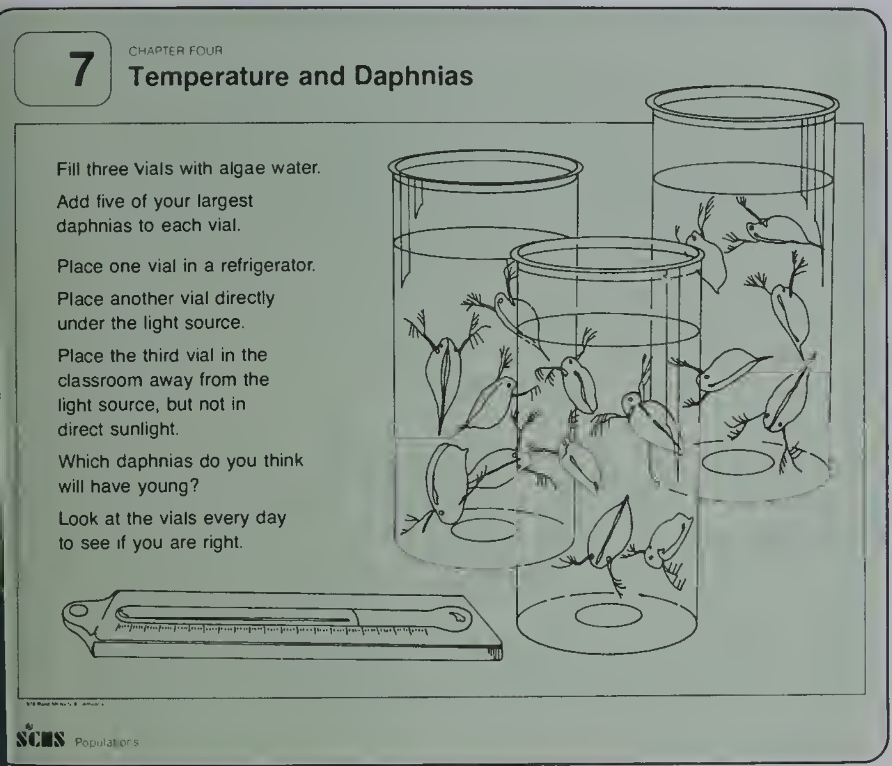
Increase and decrease in number. During each recording session, invite the children to tell you what has happened to the daphnias in their vials. Use their results to start a discussion:

- If the number of organisms has increased, ask where the new daphnias might have come from. Someone may suggest that the organisms have reproduced.
- Ask, "How many daphnias were born since the last time we counted them?" The students will have to subtract the previous number of daphnias from the latest count. (The result is only approximate, because some daphnias may have died between counts.)
- If the number of daphnias have decreased in any of the vials, ask the children what might have happened. If no one suggests that some daphnias have died, you should mention this.
- Ask what would happen to the number of daphnias in a vial if more animals died than were born. Then ask what would happen to the number of daphnias in a vial if there were more births than deaths.

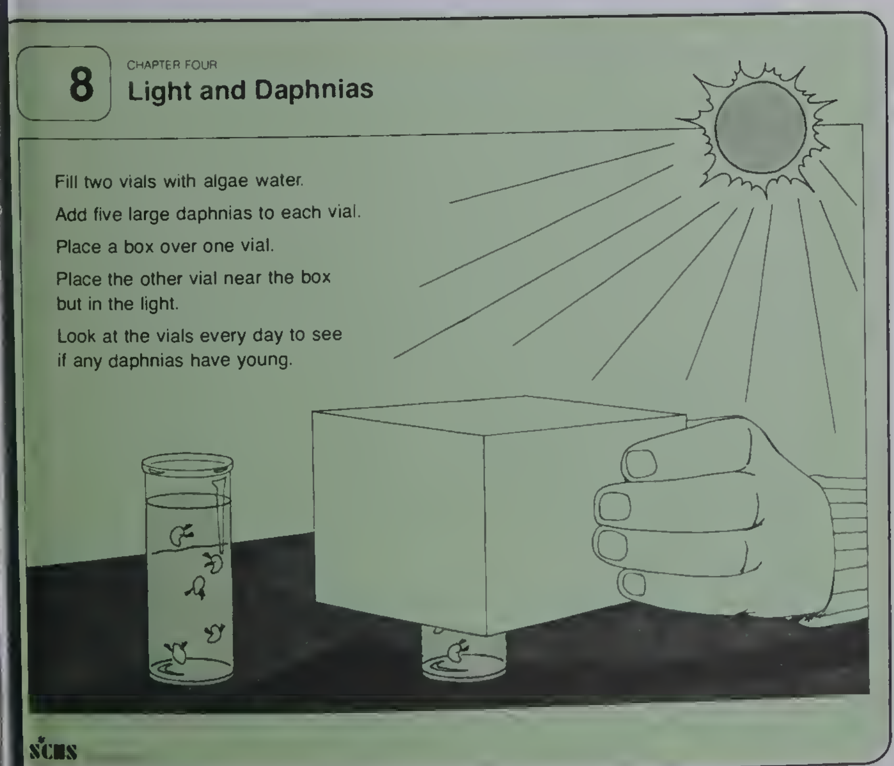
Cleanup. After the daphnia numbers have decreased and the counting and recording are completed, use a dip net to return any remaining daphnias to the class culture for use in Chapter 6. Empty the vials, rinse them, and return them to the kit. Save the graph for use in later chapters.

EXTENDING YOUR EXPERIENCE CARDS

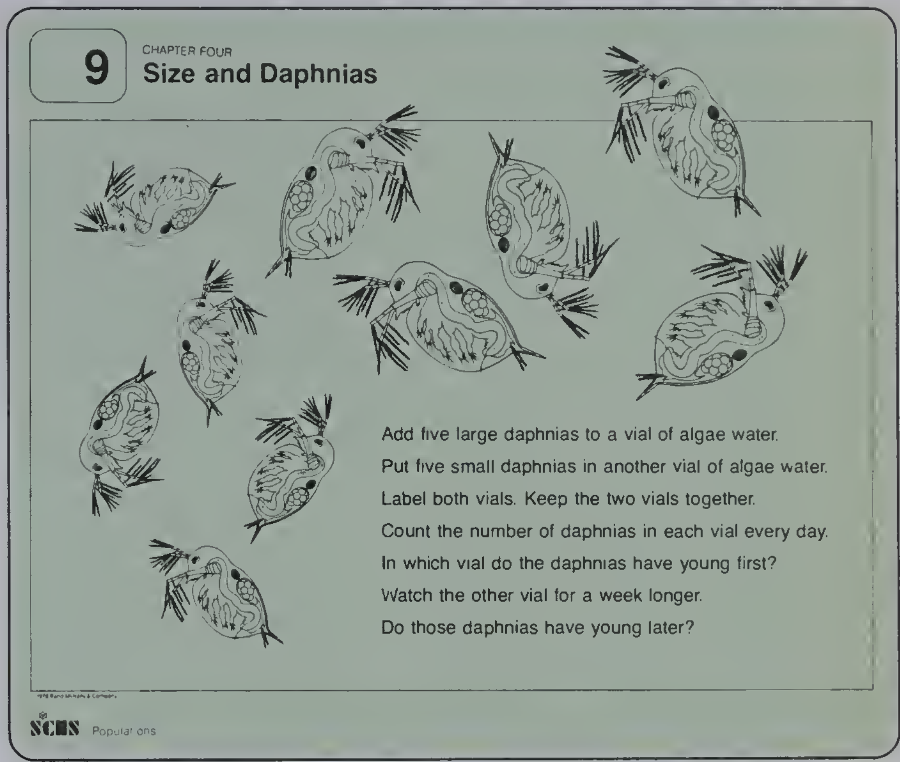
7. Temperature and Daphnias. After your students notice that the number of offspring produced by parent daphnias varies, they may be interested in the cause of the variation. This activity is concerned with one possible cause. A child carrying out this activity will need to use a refrigerator, a thermometer, 15 daphnias, and 3 vials of algae water.



8. Light and Daphnias. This activity, like the preceding one, is concerned with the causes of variation in the reproduction of offspring by daphnias. Two vials of algae water, 10 daphnias, and a box are needed.



9. Size and Daphnias. Only adult daphnias produce young. It is difficult to determine by inspection whether or not a particular daphnia is an adult. Nevertheless, the very small individuals are probably immature and not yet able to reproduce. The student will need 10 daphnias and 2 vials of algae water.



5 "Inventing" the Population Concept

SYNOPSIS

Children count aphids and record the data on a chart and graph.

The population concept is introduced.

Suggested time: ***about three weeks***

TEACHING MATERIALS

For each team of two children:

1 planter cup containing peas (prepared in Chapter 2)

Drawer 2

1 magnifier

Drawer 3

1 pipe cleaner

Drawer 5

2 pea seeds

For the class:

pea aphids†
colored construction paper*
scissors*
tape or paste*
ruler*

Drawer 1

Aphid chart
Aphid graph

Drawer 2

2 light sources

Drawer 3

8 plastic tumblers
fava bean plants (from Chapter 2)

Drawer 5

4 water sprinklers

* provided by the teacher
† in Shipment P-1

ADVANCE PREPARATION

Post the Aphid chart and list the team members' names in the spaces provided. Record the date in the day 0 (zero) column.

TEACHING SUGGESTIONS

Observing and counting aphids continues the exploration of populations. This is followed at the end of the chapter by the invention of the population concept.

Transferring aphids. Tell your students that they will place aphids on the pea plants. Over the next three weeks they will count the number of aphids on the plants to determine if the number has increased or decreased.

Though transferring the aphids is not a simple job, your students will be more interested in the animals if they carry out the transfers themselves than if you do it for them.

Aphids can survive for only a short time when they are away from the plants. Therefore, distribute them only after the teams have obtained their planters and you have demonstrated the transfer technique pictured in Figure 5-1.

- While the children obtain their plants and pipe cleaners, take out a tumbler for each two or three teams.
- Hold an opened shipping capsule above one of the tumblers and use a pipe cleaner to gently push five or six aphids into the tumbler.
- Repeat the process with the remaining tumblers.
- Distribute these tumblers to the teams and ask the children to transfer one or two aphids to each pea plant.
- To establish a reserve supply of aphids, have some pupils transfer some of the extra aphids to the fava bean plants you prepared in Chapter 3.
- Water the bean plants in the shipping container to maintain any remaining aphids.
- When the students have completed the transfer, encourage them to observe the aphids with their magnifiers. Ask, "How many legs do aphids have? Do they move around on the plant, or do they remain in one place?"
- After about five minutes of observation, distribute two pea seeds to each team and tell the children to plant them in the soil near the other plants. (New seedlings should appear in about one week.)
- The teams should water the soil in the planters, being careful not to knock the aphids off the plants.
- The children should carefully put their planters back near the light source, but not directly under the bulb.

Figure 5-1. Gently roll a pipe cleaner beneath an aphid, lifting the aphid off the plant, and lower it onto a second plant in the same manner.

Recording on the chart and graph. The members of each team should find their names on the class chart and record the number of aphids they transferred to the plants in the day 0 column.

Young aphids will appear soon, so plan to have the students observe and count them every two or three days and record the total in the next available column. Before each recording session, write the date and the number of days elapsed since the start of the experiment at the top of the next available column. Continue the observation and counting until there is a marked change (about three weeks from day 0).

At each counting and recording session, appoint children to transfer data from the chart to the Aphid graph. Use the procedure described for the Daphnia graph in Chapter 4.

Observing aphids. Encourage the students to observe their aphids during each counting session.

- Someone may notice an aphid giving birth. (Baby aphids are extruded from the posterior of a female aphid.)
- Some children may observe the young aphids molting or notice dry, white objects (molted skins). Instead of telling what these are, suggest that they examine one with a magnifier.

Figure 5-2. Recording numbers of aphids.

Figure 5-3. Using their magnifiers to observe the aphids, your students can informally learn about the animals' structure and behavior.

Figure 5-4. The white, cottony things that appear near aphids are not new animals or dead aphids, but molted aphid skins.

- Encourage the children to find out how aphids eat. With the aid of magnifiers, children will be able to see the long, pointed snout that extends from the aphid's head to the plant surface, but they may not infer that this structure is used for eating.

"Inventing" ***population.*** After the data show a decrease in the number of aphids, gather the students for a discussion.

- Point out that the numbers of daphnias and aphids have changed from day to day.
- Ask, "What might have caused these changes?" (Is it clear to the students that the increase in the number of organisms is related to the production of offspring, and that decrease, to death.
- Explain to the class that a group of organisms of the same kind living and reproducing in the same place is called a *population*.
- Write the term on the chalkboard and let the class pronounce it.
- Tell the students that population size is determined by the number of individuals, not by their physical size.
- Explain that the daphnias in each vial constitute a daphnia population and that, in like manner, a population of aphids lives on the plants in each planter.
- Request the children to name populations of organisms in the area where they live or in other places. Are the children themselves a part of a population?

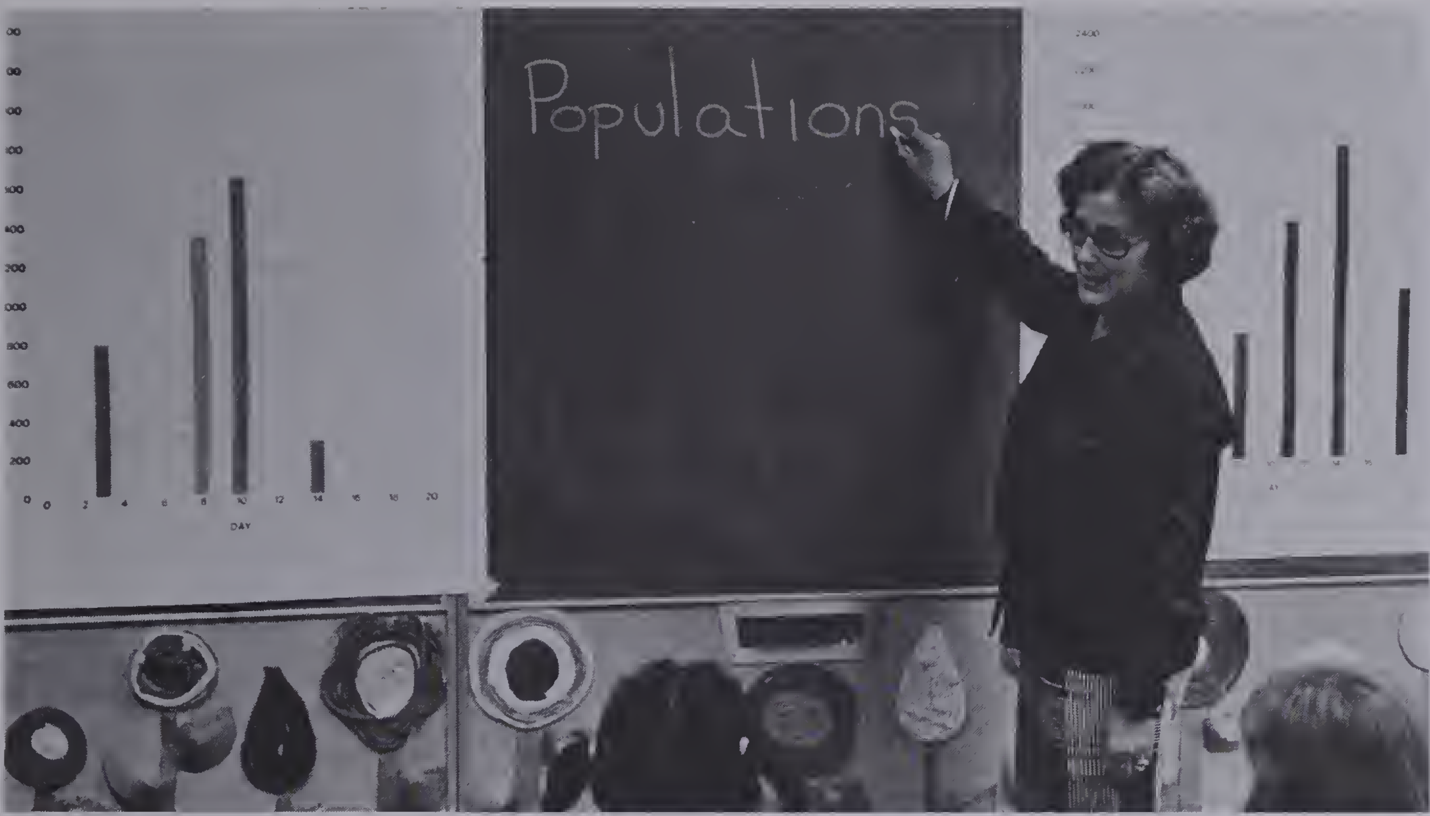


Figure 5-5. "Inventing" *population*.

Maintaining aphids. You will need aphids for the terrarium activities in Part Three. To insure a continuous supply of food for aphids, have your pupils plant new seeds alongside the existing plants every four or five days. Observe the new seedlings to see if aphids are moving to them.

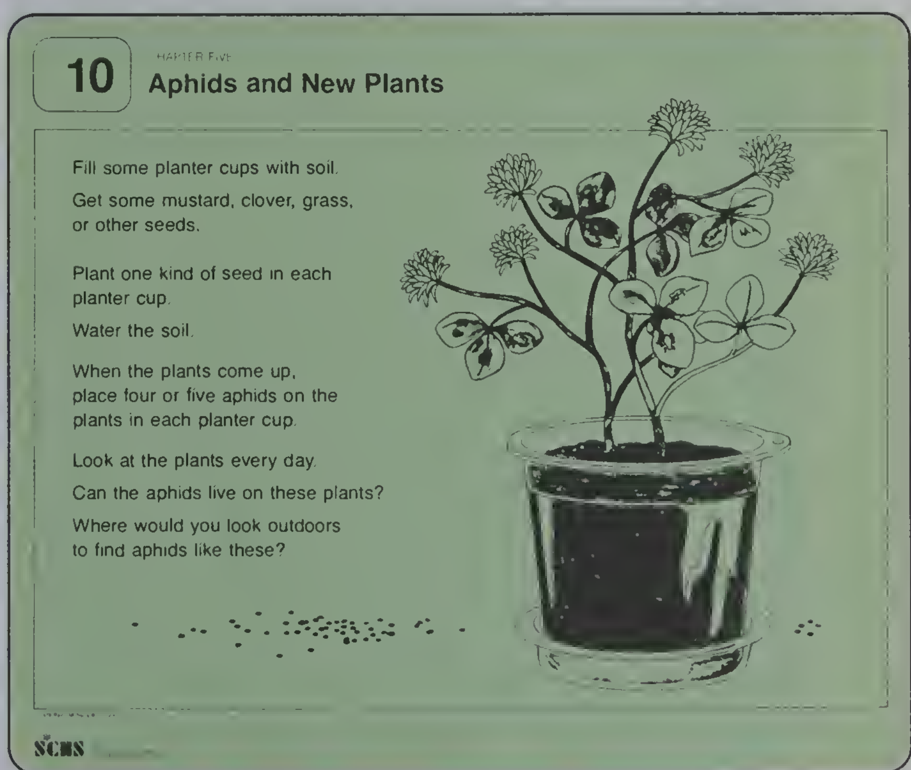
OPTIONAL ACTIVITIES

Local aphids. Some children may wish to collect aphids that are native to your area. Once they discover a source of aphids, such as rose bushes or fruit trees, the children can determine if the new aphids will survive on their pea plants or live with their pea aphids. Have them use pipe cleaners, plastic bags, and twistems for collecting the insects.

EXTENDING YOUR EXPERIENCE CARD

10. Aphids and New Plants. Aphids, like other plant parasites, are usually adapted to feeding and living on only a few kinds of plants, so they will probably not survive on other kinds of plants in the classroom. This activity demonstrates the principle that animals requiring a special kind of food can only live where that food is available.

Caution any child using this card not to free the aphids outdoors. Planter cups, various seeds, and aphids will be needed.


10 Aphids and New Plants

Fill some planter cups with soil.

Get some mustard, clover, grass, or other seeds.

Plant one kind of seed in each planter cup.

Water the soil.

When the plants come up, place four or five aphids on the plants in each planter cup.

Look at the plants every day.

Can the aphids live on these plants?

Where would you look outdoors to find aphids like these?

SCIS

6 Dispersal

SYNOPSIS

Children observe aphids crawling in the area where plants are stored or elsewhere in the classroom.

The terms* dispersal *and* barrier *are introduced.

Daphnia dispersal is demonstrated.

Suggested time: ***two days***

TEACHING MATERIALS

For each team of four children:

20 daphnias

Drawer 3

2 tumblers
1 piece of plastic tubing 15 cm long
1 plastic tube holder

Drawer 4

1 six-liter (or other) container for water

For the class:

algae culture

TEACHING SUGGESTIONS

The children's observations of aphids moving about the classroom provide the basis for invention of the dispersal and barrier concepts.

Introducing the concepts *dispersal* and *barrier*. When a team reports that aphids have moved to new pea seedlings, gather your pupils for a discussion. By this time, children may have observed aphids crawling in the area where the plants are stored or elsewhere in the classroom.

- Ask, "Why do you think some aphids are moving away from the pea plants?"
- You can expect simple inferences based on their observations. Typical responses are: "The old plants are dying," "The aphids are overcrowded," "New plants are better," and "The aphids will die if they don't move."
- Explain that when individuals move from the area the population occupies to some other area, we call this *dispersal*.
- Write the term on the chalkboard and explain that the aphids are dispersing.
- To help the children understand the result of dispersal, ask them questions like these: "What might happen to the aphids that disperse?" "What might happen to those that don't disperse and continue to reproduce?"
- Ask why the daphnias didn't disperse to different vials when they became crowded. The children will probably mention the lack of water between the vials.
- Then explain that anything that prevents dispersal is called a *barrier*.
- Write the term on the chalkboard and request children to describe barriers to aphid dispersal in the classroom. You might also request them to suggest barriers to dispersal of organisms outdoors.

Dispersal of daphnias. Give each team a container for water, two tumblers, one plastic tube, and one plastic tube holder. Then demonstrate how to set up the experiment as follows:

- Fill each of the tumblers to the lower edge of the frosted rim with algae water. Place the tumblers on a table or windowsill where they can be left undisturbed, with a distance of 3 cm (1¼ in) between the tumbler rims.
- Fill the container with aged tap water.
- Add 15 to 20 daphnias to one tumbler.
- Push one end of the plastic tube through one hole in the plastic tube holder so that it extends about 3 cm (1¼ in) beyond the holder.
- Bend the tube and repeat the operation with the other end of the tube and the other hole in the holder.

Figure 6-1. The plastic tube must be filled with water.

- Fill the plastic tube completely by lowering the entire tube into the container with the open ends of the tube up.
- There should be no air in the tube.
- Place one finger at each end of the tube, closing off the openings.
- Invert the tube and plastic sheet, and dip one end of the tube into each of the two tumblers.
- Release the tube ends. Let the tube and holder rest on the tumblers.

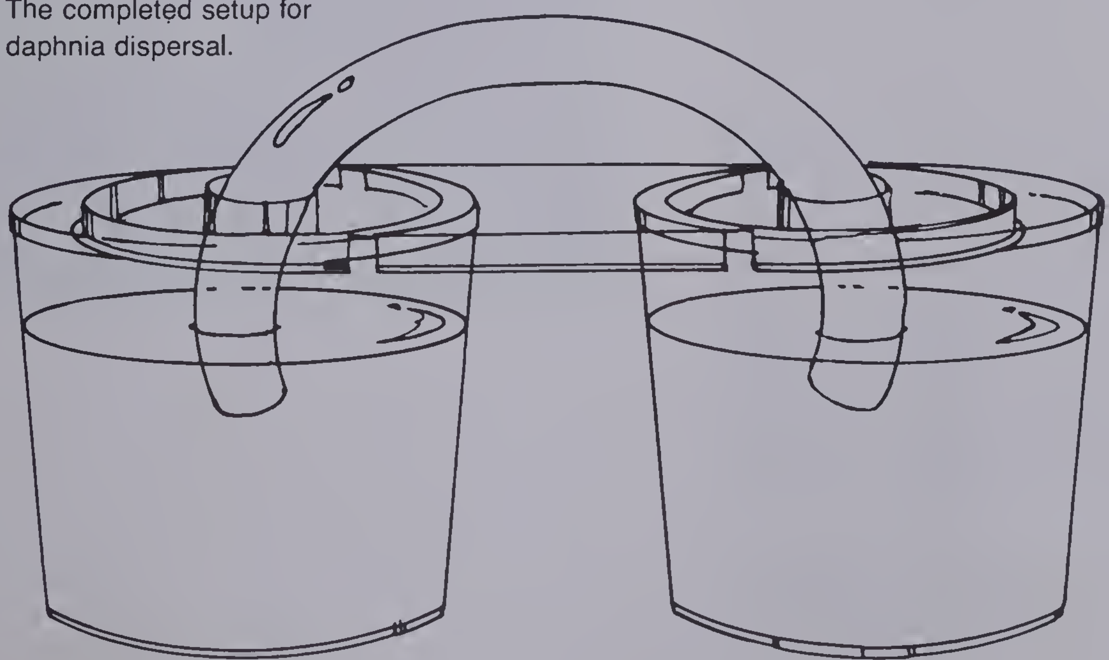
If this operation has been performed correctly, you will now have a tube of water connecting the algae water in the two tumblers. If a large bubble of air appears in the tube, repeat the procedure. If the bubble is so small that it does not block the tube, don't be concerned about it. It probably will not keep the daphnias from moving through the tube.

Tell each team to write their names on the frosted rim of one of the tumblers. Leave the experimental setup where it is. Let the children observe the daphnias from time to time during the day.

On the next day, let the children observe their experiment again. By this time at least one or two daphnias should have moved to the other tumbler. If not, wait another day.

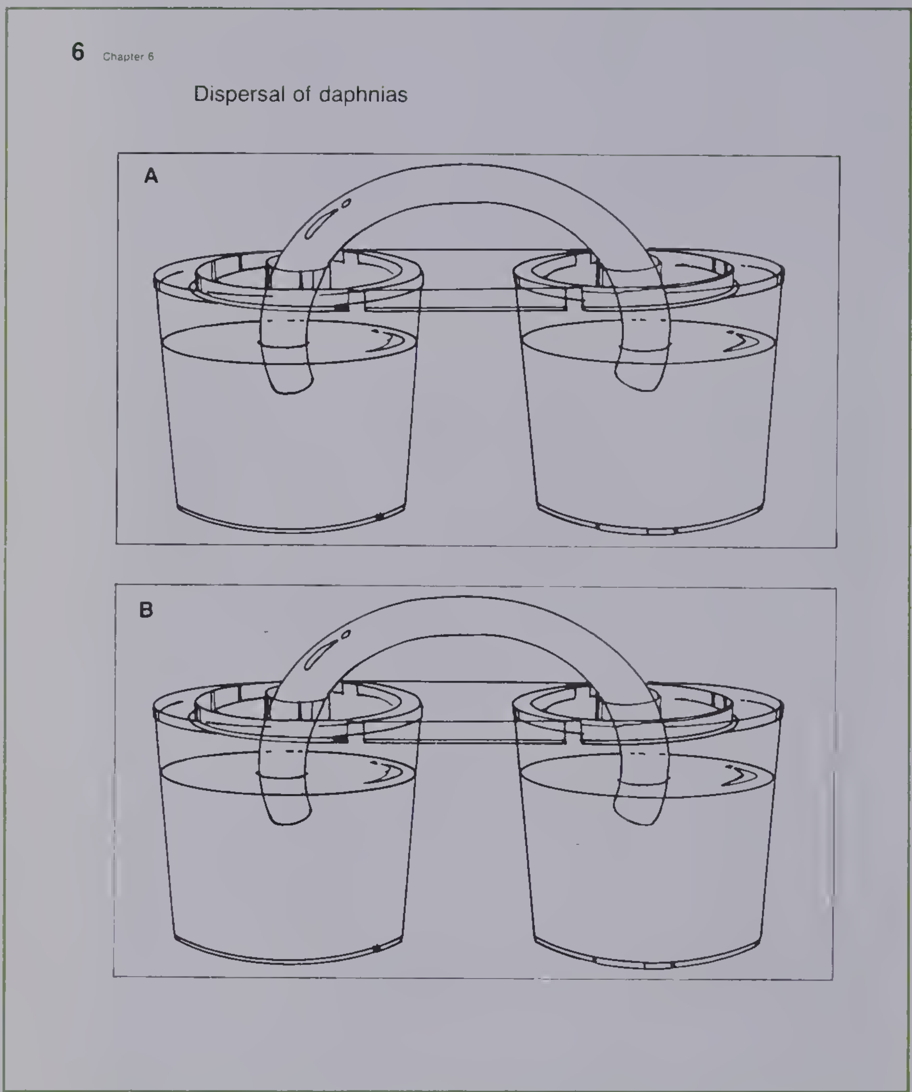
- Ask the students how the daphnias got into the second tumbler. Do they think the daphnias knew that the tube led to another tumbler containing algae water, and that they swam through the tube on purpose?
- If not, what explains their moving to the other tumbler?

Figure 6-2. The completed setup for daphnia dispersal.



- To help the children answer this question, encourage them to watch the movements of daphnias in the tumbler and to observe the experiment as long as they are interested.

Using student manual page 6. Ask the children to draw daphnias in the pictures of the tumblers to show what happened in their experiment. Picture *A* should show the beginning of the experiment, and Picture *B* the end.



OPTIONAL ACTIVITIES

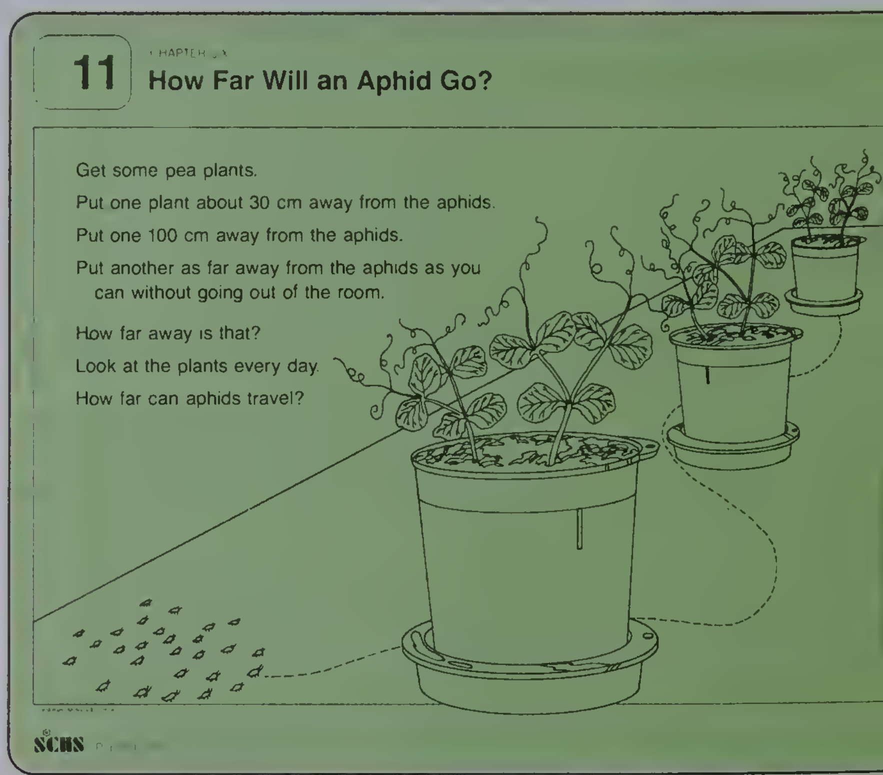
Aphid barriers. Starting with the pea plants and aphid population in one planter cup, challenge the students to find out what conditions will act as barriers to their dispersal. You will need a fresh pea plant for each condition to be tested. The children may suggest putting a wall between the aphid population and the new plant, separating them with water, putting insecticide on the new plant, placing the new plant in the dark during the experiment, putting ice cubes on the new plant, and so on. Encourage any suggestions that can be tested.

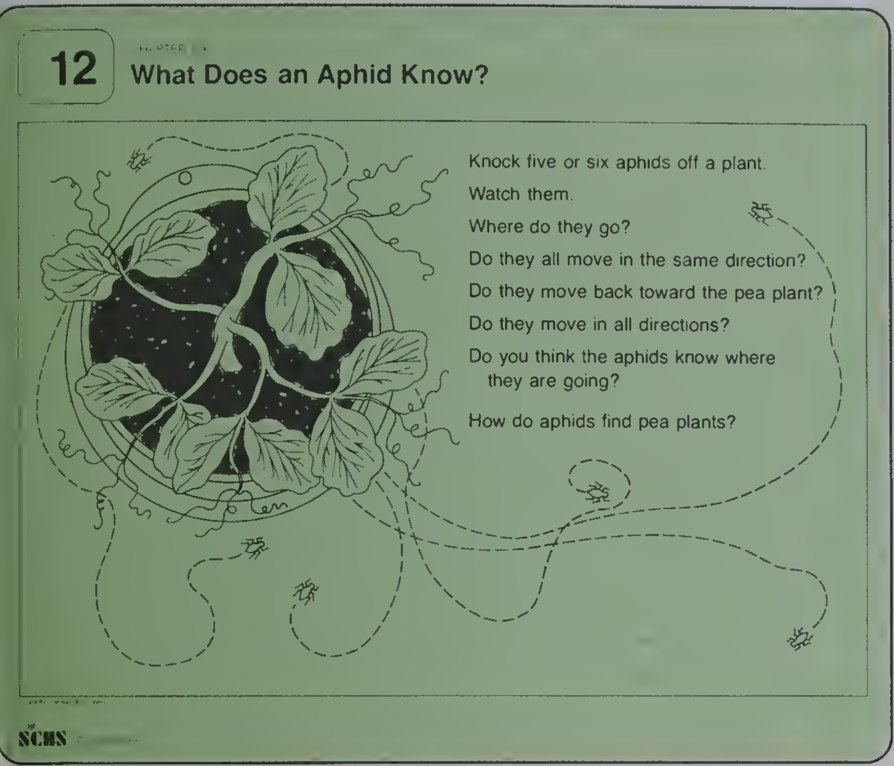
Daphnia barriers. Similarly, the basic daphnia-dispersal setup can be modified for testing several barriers. The plastic tube might contain no water, salt water, water without algae, or ice water; the second tumbler might contain a hungry goldfish or hot water.

EXTENDING YOUR EXPERIENCE CARDS

11. How Far Will an Aphid Go? This experiment will provide no final answers to the question, but it will probably demonstrate that these tiny insects can travel relatively great distances. Some extra pea plants will be needed.

12. What Does an Aphid Know? It would be difficult to discover whether or not aphids know anything. However, aphids removed from a plant appear to move at random, so it is probably an accident that aphids find new plants.





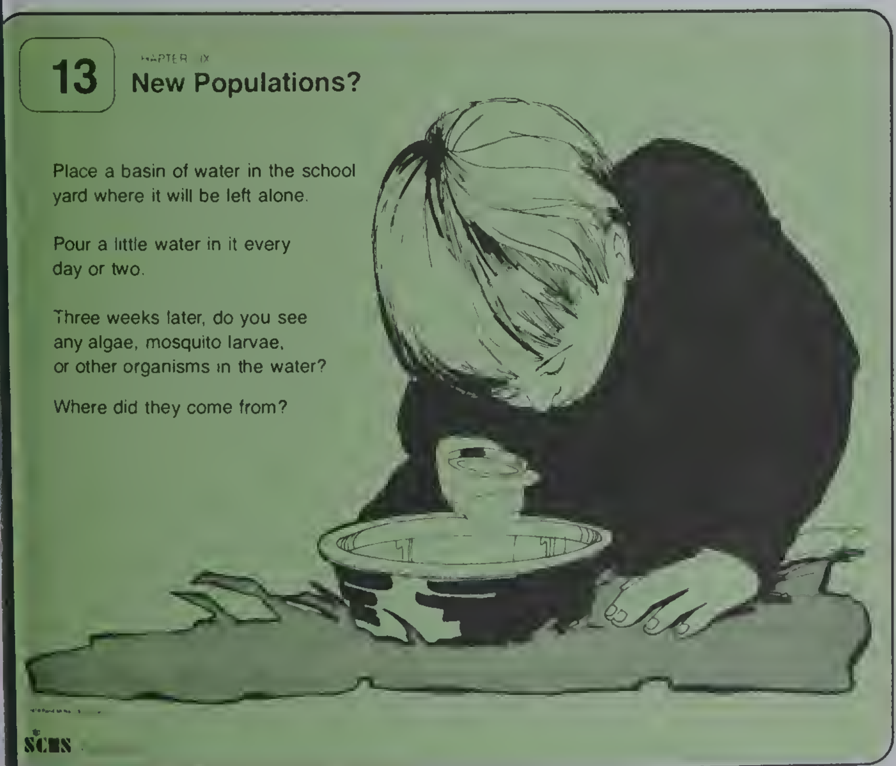
CHAPTER SIX

12 What Does an Aphid Know?

Knock five or six aphids off a plant.
Watch them.
Where do they go?
Do they all move in the same direction?
Do they move back toward the pea plant?
Do they move in all directions?
Do you think the aphids know where they are going?
How do aphids find pea plants?

SCIS

13. New Populations? Plants and animals enter a new territory by dispersing from some other locality. Thus, when your students observe algae, insects, or some other form of life in their basin of water, they should infer that these organisms have dispersed.



CHAPTER SIX

13 New Populations?

Place a basin of water in the school yard where it will be left alone.

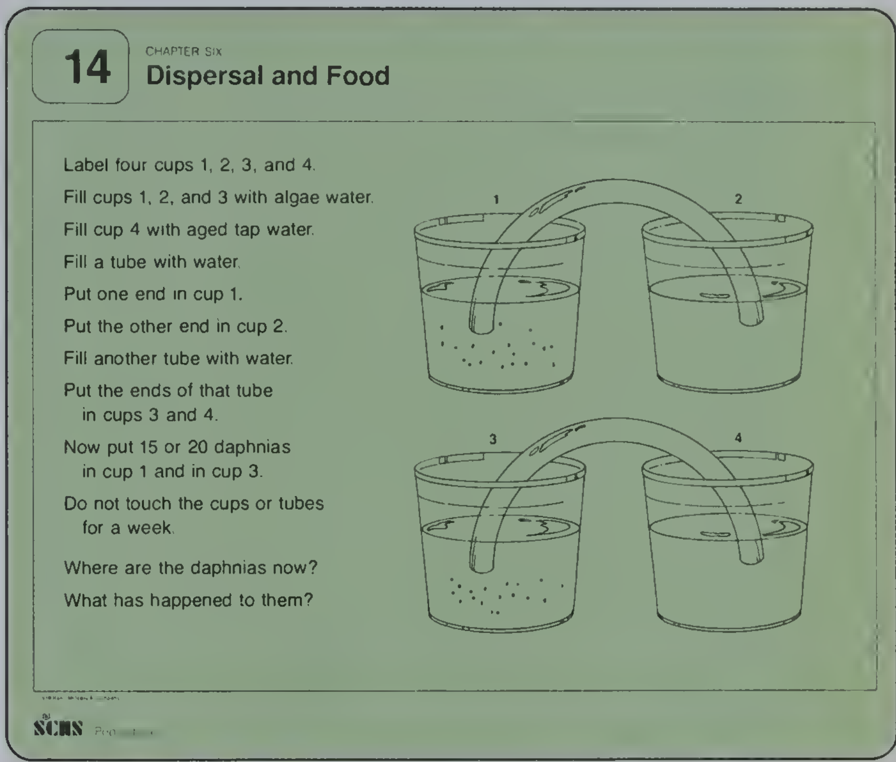
Pour a little water in it every day or two.

Three weeks later, do you see any algae, mosquito larvae, or other organisms in the water?

Where did they come from?

SCIS

14. Dispersal and Food. The daphnias that dispersed into plain water probably died. This experiment is designed to demonstrate the primary importance of a food supply to the survival of any population. The child who carries it out will need 2 dispersal setups and 30 or 40 daphnias.



CHAPTER SIX

14 Dispersal and Food

Label four cups 1, 2, 3, and 4.
Fill cups 1, 2, and 3 with algae water.
Fill cup 4 with aged tap water.
Fill a tube with water.
Put one end in cup 1.
Put the other end in cup 2.
Fill another tube with water.
Put the ends of that tube in cups 3 and 4.
Now put 15 or 20 daphnias in cup 1 and in cup 3.
Do not touch the cups or tubes for a week.
Where are the daphnias now?
What has happened to them?

SCIS

7 What Caused the Population Decrease?

SYNOPSIS

Children set up experiments to investigate possible causes for population decrease.

Suggested time: ***two sessions over a week or two***

Chapter 7

TEACHING MATERIALS

For the class:

The materials needed will vary depending on the kinds of experiments the children design. The following list includes most of the items they will need.

- 8 to 10 jars*
- algae culture
- daphnia culture
- aged tap water
- Daphnia graph (from Chapter 4)
- Aphid graph (from Chapter 5)
- scissors*
- tape or paste*
- ruler*
- construction paper (two colors)*

Drawer 2

- vials

Drawer 3

- labels
- plastic tumblers
- medicine droppers
- daphnia counters

Drawer 6

- dip net
- baster

* provided by the teacher

BACKGROUND INFORMATION

In this chapter, the students conduct controlled experiments to investigate the reason for decreases in the daphnia populations.

A controlled experiment consists of two setups in which all conditions (variables) with the exception of one are identical. Any difference in the result obtained in the experiment can then be attributed to the one variable being tested. If, for example, children think that lack of light caused the decrease in daphnia populations, light is then made a variable to be investigated; one setup is placed in the light and the other in the dark. The other variables—number of daphnias, amount of algae water, and size of the container—would have to be alike in both setups. Any differences the pupils observe in the daphnia populations must then be attributed to the amount of light present.

By comparison, in an uncontrolled experiment there are differences in more than one condition. For example, children testing the effect of living space on daphnia populations may suggest using both large and small containers filled with algae water. But the larger container has more food as well as more space for the organisms, which adds another variable. To test only the space variable, they would have to pour the same amount of algae water into each container, then add tap water to the larger one. That would increase the living space, but not the food supply.

ADVANCE PREPARATION

Obtain eight to ten baby food or jelly jars and wash them in warm water. These may be used as daphnia containers in a space experiment.

Using the dip net and baster, transfer about ten daphnias to each of eight tumblers of algae water (see page 18 for a description of the technique).

TEACHING SUGGESTIONS

This is an exploratory activity. The children experiment to try to find the cause of a decrease in size of the daphnia population.

Discussion. When either the aphid or daphnia population shows a decrease after an initial increase, gather your students in front of that graph for a discussion. Review the concept that increase in the number of aphids or daphnias occurs because of reproduction. Then ask what might have happened to cause the decrease. Someone should suggest that some daphnias or aphids have died.

Invite your students to give reasons that might account for the death of the daphnias. They will probably mention lack of food (algae), too much or too little

light, water that was either too hot or too cold, and not enough living space.

- List the pupils' ideas on the chalkboard and write "Variables" above the list.
- Pronounce the term "Variables" and ask the children if they know the meaning of the term. Children who have had the *Subsystems and Variables* unit will be familiar with the term.
- If any of your students do not know the meaning of the term, tell them that variables are conditions in an experiment that can be changed. Changing a variable may affect the results of an experiment.
- As an example of a variable, point to one of the items in the list on the chalkboard, such as food. Ask the children if they think the amount of food available in the daphnia vials could change from day to day.
- Point to each item in the list in turn and ask the children how that particular variable might change.
- Then ask for their ideas about how they could change the variables.
  Then ask for their ideas about how they could change the variables.

Planning experiments. Have the teams select one variable that they wish to investigate. If you and the children prefer having all teams investigate the same variable—such as light—have the entire class design the experiment in a discussion. On the other hand, if different teams want to investigate different variables—one team investigating light and another food supply, for example—let team members plan their own experiments. Setups for testing two variables are pictured in Figures 7-1 and 7-2.

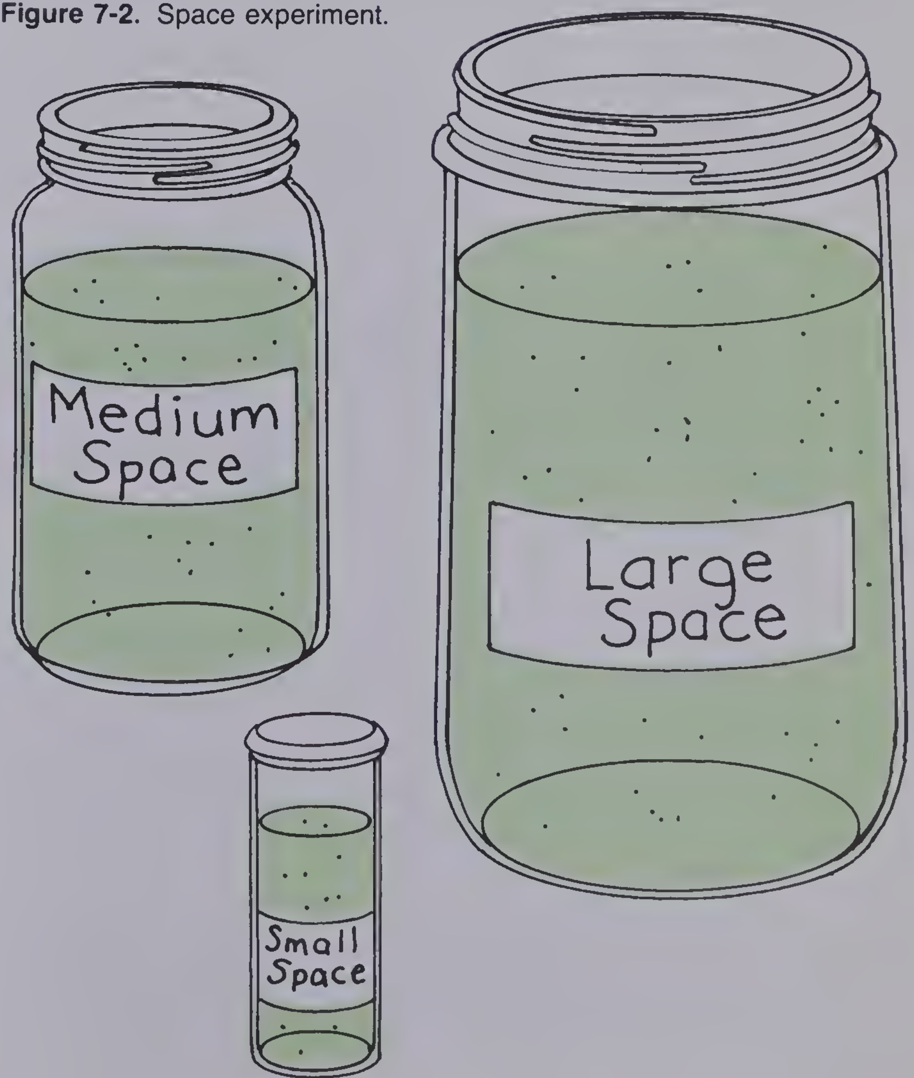
Whichever approach you use, it may be necessary for you to help the students think through the various phases of the experiment by asking questions such as the following:

- "Have you decided on the equipment you will use?"
- "How many daphnias will you use?"
- "What kind of evidence do you need to see the effect of changing the variable?"
- "How will you know that your results are not because of some other variable in your experiment?"

Setting up the experiments. Tell the children they may work in teams, and then make the required materials available. Children of this age may be able to plan an experiment, but they may not be able to set up the experiment according to their own plans. Walk among them while they are setting up their experiments. If you notice a team failing to control a variable, point it out to them and ask what effect this will have on their results.

Figure 7-1. Food experiment.

Figure 7-2. Space experiment.



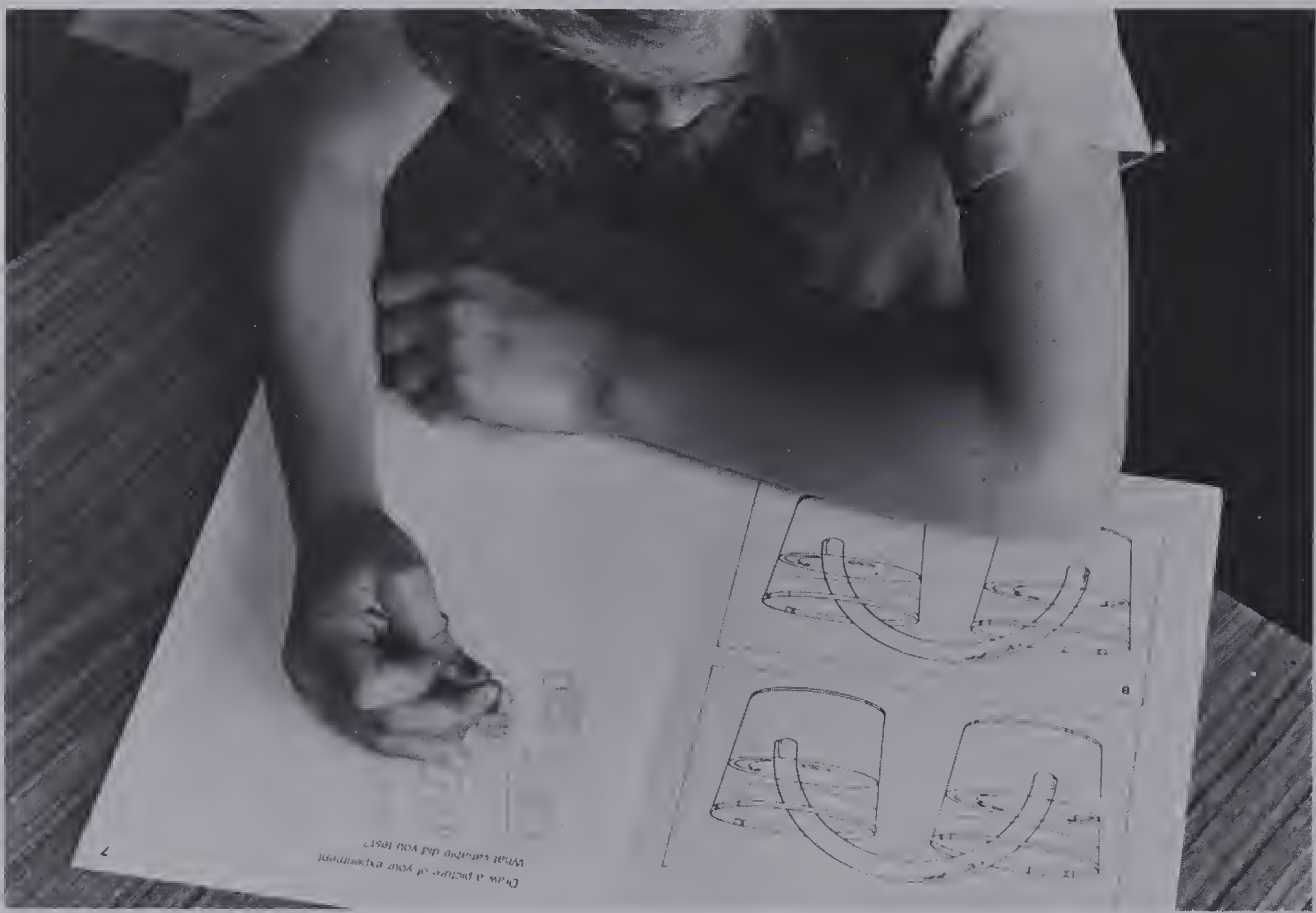


Figure 7-3. Picturing an experiment in the student manual.

Encourage the teams to observe their experiments over the next week or two.

Analyzing the results. If the teams are conducting experiments on different variables invite them to share the results. Suggest that the teams who tested the same variable get together, combine their results, and report these to the class. Then the class can form a conclusion from the evidence presented.

If all the teams are investigating the same variable, the Daphnia graph from Chapter 4 can be used to display the results. Remove the strips of paper from the graph and cut narrow strips of paper in two different colors. One color can represent food (or light, or larger space) and the other can represent no food (or no light, or smaller space).

Because the pupils started their experiments with equal numbers of daphnias in the two setups, the pair of strips for day 0 will be the same length. Determine the total number of daphnias that the class used at the beginning of the experiment, cut the strips this length, and tape them side by side on the vertical line for day 0.

Determine the population sizes on the last day of the experiment and place strips side by side on the vertical line representing that day. The children can use these graphed data to draw their conclusions.

Chapter 7 7

Draw a picture of your experiment.

What variable did you test?

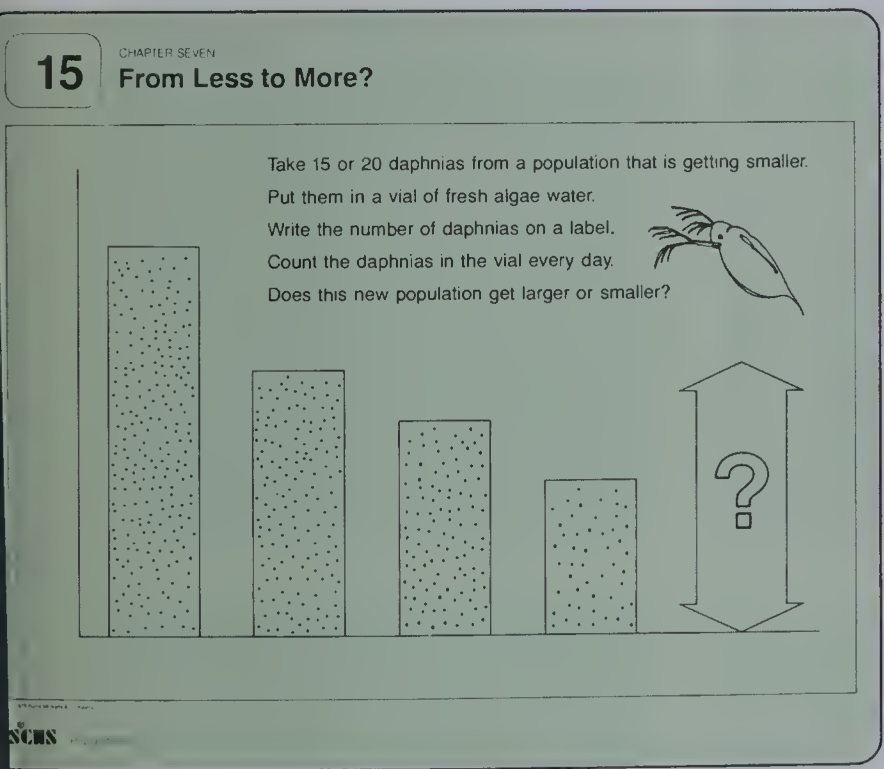
Using student manual page 7. Ask the children to draw a picture of their experiment, name the variable they tested, and record the results.

Cleanup. There is no further need to maintain the cultures of algae and daphnias. However, other classes in your school may be able to use these organisms. Daphnias are excellent fish food and can be added to classroom aquariums or given to children for their home aquariums.

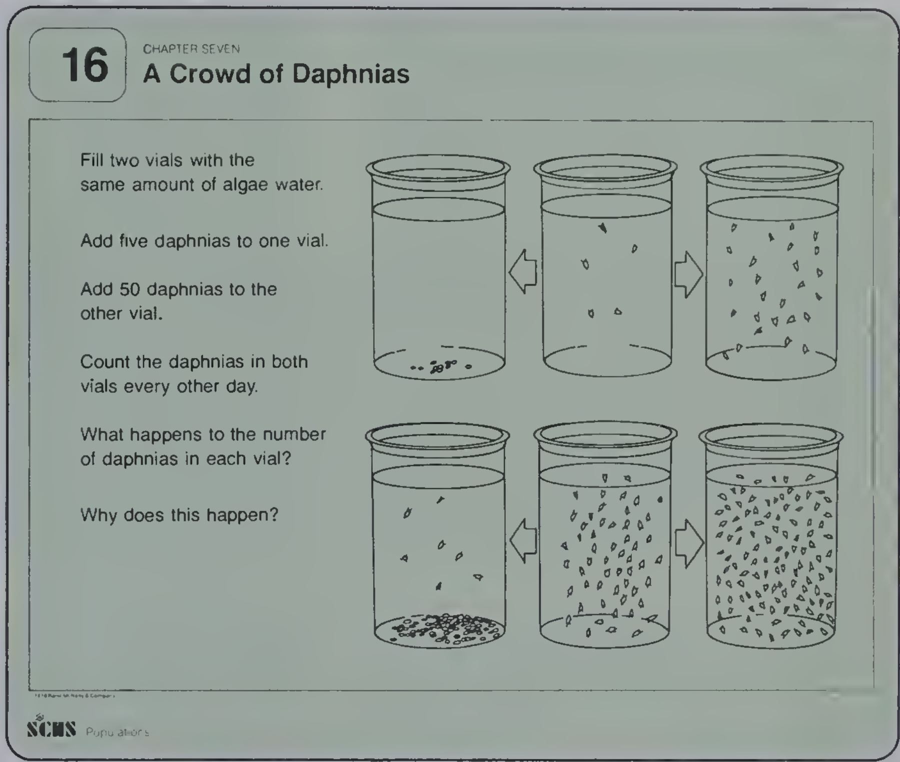
Rinse the containers and vials and return them to the kit.

EXTENDING YOUR EXPERIENCE CARDS

15. From Less to More? The population will probably increase. Many factors (such as temperature, food, chemicals in the water, and amount of space) could affect the growth of the daphnia population. By providing a new environment for the daphnias, the child can probably eliminate the factors that caused the population decrease. A vial of algae water and 15–20 daphnias from a decreasing population will be needed.



16. A Crowd of Daphnias. Populations can get too large for the space in which they live, so the large population of daphnias probably will begin to decrease. This activity is designed to emphasize that the size of a population is a significant factor in the survival of the population. The child carrying it out will need 55 daphnias and 2 vials of algae water.



Extending Your Experience cards 1–16 are now available for the children's use. For materials needed, refer to the equipment list accompanying the set of cards.

CONCEPT / PROCESS EVALUATION

If you choose to evaluate the children's understanding of the concepts of (1) population and (2) the causes of changes in populations, turn to pages 76 and 77 of the evaluation section at the back of the guide.

Part Two

RAND McNALLY

SCIIS

Growing Populations

OBJECTIVES

To predict a vast increase in the numbers of organisms if all offspring survive in each generation.

To understand that certain factors limit the numbers of plants and animals surviving in each generation.

BACKGROUND INFORMATION

Populations of organisms remain stable if the number of births equal the number of deaths and if no organisms enter or leave the area. But if there are more births than deaths, the size of the population increases. Conversely, if there are more deaths than births, the number declines.

All species of organisms have an enormous capacity to reproduce. This capacity is reflected in the term "biotic potential," which is defined as the theoretically largest possible increase in any population of organisms if one assumes a maximum number of births and no deaths. The biotic potential of a population is never fulfilled because death (due to disease, starvation, and predation) occurs. However, whenever the death rate declines, a particular population increases.

The human population is the best example of the biotic potential phenomenon. Humans have few predators (other than fellow human beings), many diseases have been overcome, and human food supplies have increased. The result has been a human population explosion.

Your students will infer the meaning of biotic potential as they carry out the activities with the daphnias and bean plants.

OVERVIEW

In Chapter 8, "Biotic Potential of Daphnias," students estimate biotic potential. They infer a large increase in the size of the daphnia population by assuming that each daphnia produces a certain number of young and that all the young become adults. In Chapter 9, "Biotic Potential of Plants," children make the same type of estimate and inferences about bean plants.

Figure II-1. Predation limits some population sizes.

8 Biotic Potential of Animals

SYNOPSIS

Children predict what would happen to the size of a population of daphnias if none of the animals died.

Suggested time: ***one session***

Chapter 8

TEACHING MATERIALS

For the class:

Daphnia chart (from Chapter 4)
Daphnia graph (from Chapter 4)

Drawer 1

Biotic Potential chart: Daphnia

TEACHING SUGGESTIONS

The children's estimate of the possible increase in the daphnia population is an exploratory activity. This is followed by invention of the biotic potential concept.

Discussion. Display the Daphnia chart and Daphnia graph. Point out that the number of daphnias increased rapidly at the beginning of the Chapter 4 experiment.

- Tell the children that each adult daphnia gives birth to 10–15 young.
- Show the picture of one adult with 10 offspring on the Biotic Potential chart: Daphnia.
- Ask, "How many daphnias would there be if each young daphnia became an adult and produced 10 offspring?"
- After most of the students have agreed on a number, show them the picture of 100 daphnias.
- Ask them to suppose that there are now 100 daphnias in the population. Again ask how many daphnias there would be if all the daphnias lived and produced 10 offspring.
- Most children will understand that if none of the offspring die, the population would increase rapidly.

Introducing biotic potential. Tell the children that the ability of a population of organisms to reproduce and increase in number is called its *biotic potential.*

- Write the term on the chalkboard and ask the children to pronounce it.
- Then ask, "Why didn't your daphnia population continue to grow?"
- The children should recognize that some daphnias die. That not only stops the growth of the population, but may actually reduce the population size.

You may wish to discuss with the children some of the reasons why populations fail to increase beyond a certain size.

Factors affecting population size. If the number of births in a population is greater than the number of deaths, the population size increases. On the other hand, if deaths outnumber births, the population size decreases. Two other factors can also change the size of populations: (1) If individuals of the same species move into an area occupied by a population, the population size increases. (2) Or, if individuals move out of an area (disperse), the population size decreases. Discuss these factors with the children.

Draw a circle about 60 cm (2 feet) in diameter on the chalkboard. Draw about 20 X's evenly spaced within the circle. Tell the children that the circle marks the boundary of the area occupied by a population of animals and that each X represents one animal.

Ask the pupils (1) what would happen to the size of the population in the area if each individual gave birth to one offspring and there were no deaths; (2) what would happen to the size of the population if 10 animals of the same kind moved into the area from the outside; (3) what would happen to the size of the population if 10 animals moved out of the area; or (4) if 10 animals died. If the children answer your questions by adding or erasing X's, they can see the effects of the four factors without having to make numerical calculations.

9 Biotic Potential of Plants

SYNOPSIS

Children predict what would happen to a growing population of bean plants if none died.

Suggested time: ***one session***

TEACHING MATERIALS

For the class:

32 bean pods (from plants planted in Chapter 3)*

Drawer 1

Biotic Potential chart: Beans

* provided by the teacher

TEACHING SUGGESTIONS

This is a discovery activity demonstrating that biotic potential is also characteristic of plants.

Using the Biotic Potential chart: Beans. Have the class count the number of beans in some pods. The bean seeds can be counted without opening the pods. (If the classroom plants did not produce pods, purchase some mature bean pods. These can even be frozen or canned.)

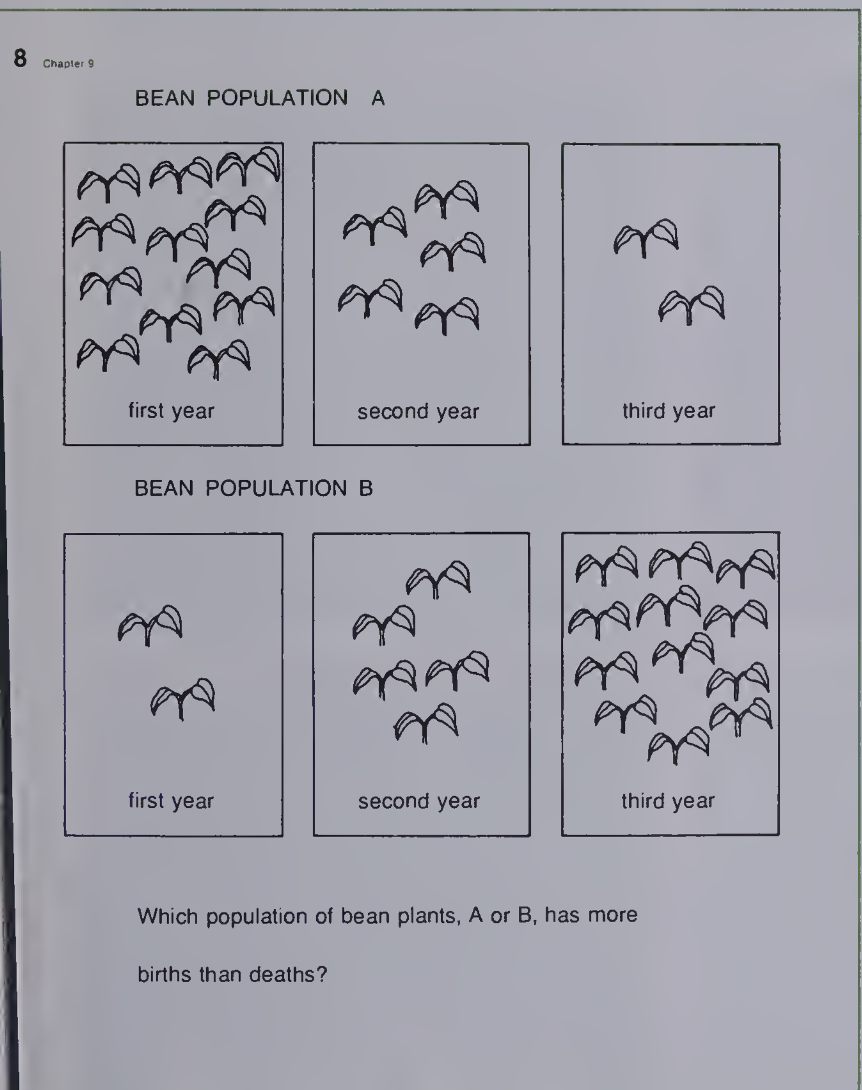
- Display the first section of the Biotic Potential chart, where one bean plant appears.
- Ask, "How many seeds do you think this plant can produce?"
- The children should base their estimate on the previous counts. Accept whatever number they propose.
- Turn to the next section of the chart and say, "This plant produced twenty seeds. How many plants would there be if each seed developed into a plant?"
- Open the chart to the section showing twenty

Figure 9-1. Using the chart.

plants. Ask, "How many seeds can be produced from these plants?"

- If they decide that each of the plants can also produce twenty seeds, the total number would be 400. (They may decide on some other reasonable estimate.)
- Display the section showing many seeds and tell the pupils this represents the number that they agreed upon.
- Ask, "How many plants would these seeds produce if they all sprouted?"
- Last, open the chart to the section showing many plants. Ask the children what would happen if all bean plants continued to reproduce like this. Then let them discuss what happens to prevent such an increase.

Using student manual page 8. Explain that the three pictures of population A show the population over a three-year period, and that the three pictures of population B show another population over the same period of time.


8 Chapter 9

BEAN POPULATION A

first year

second year

third year

BEAN POPULATION B

first year

second year

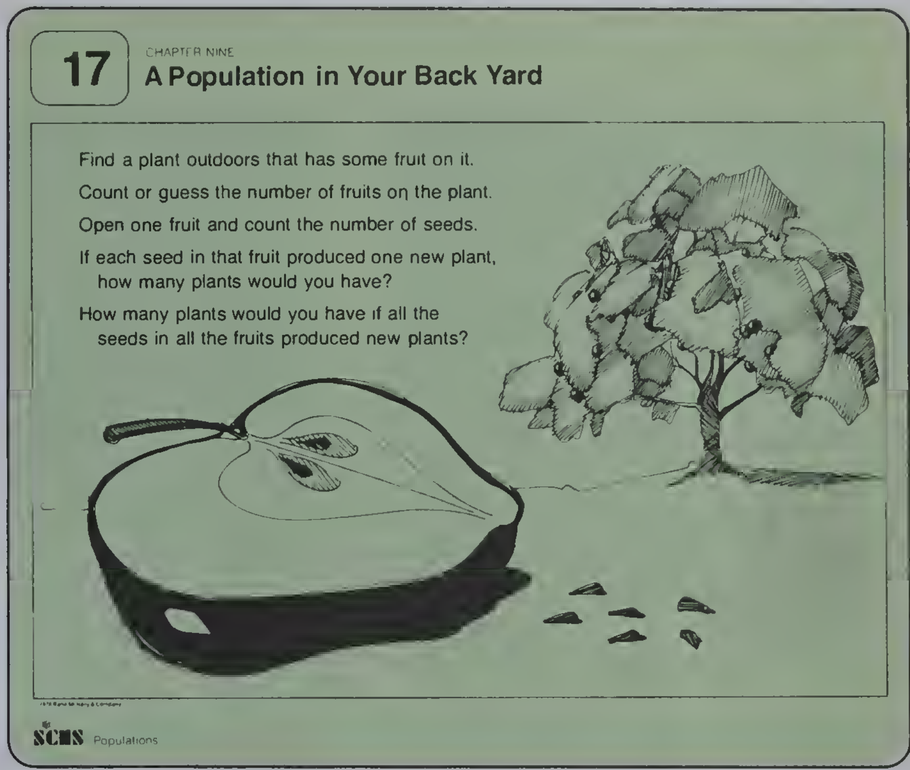
third year

Which population of bean plants, A or B, has more

births than deaths?

EXTENDING YOUR EXPERIENCE CARDS

17. A Population in Your Backyard. This activity extends the children's biotic-potential experience beyond the classroom.


17 CHAPTER NINE

A Population in Your Back Yard

Find a plant outdoors that has some fruit on it.

Count or guess the number of fruits on the plant.

Open one fruit and count the number of seeds.

If each seed in that fruit produced one new plant, how many plants would you have?

How many plants would you have if all the seeds in all the fruits produced new plants?

SCIS Populations

Extending Your Experience cards 1-17 are now available for the children's use. For materials needed, refer to the equipment list accompanying the set of cards.

Part Three

Populations on Land

OBJECTIVES

To identify the interactions among populations of plants, plant-eaters, and animal-eaters.

To diagram feeding interactions among populations of plants and animals as a food web.

To describe the interactions between predator and prey.

To identify plants and animals as the source of human food.

BACKGROUND INFORMATION

Plants and animals that live in the same area interact in a variety of ways. For example, trees are nesting places for birds; various plants provide shade and cover for animals; animals fertilize the soil with their excreta, aiding the growth of plants. But of all interactions, the most fundamental one involves food.

All plants and animals require food to maintain their life processes. Plants can make their own food, but animals cannot. Thus, wherever there are populations of animals, there must also be populations of plants on which they feed. If some of the animals eat other animals rather than plants, that is called a predator-prey relationship. In that case, three populations must be present: predator, prey, and plants.

The food relationship among populations of plants, plant-eaters, and animal-eaters is called a food chain. For example, one food chain among populations in a forest can be diagramed:

oak trees → caterpillars → warblers

The arrows indicate the direction of food transfer.

Feeding relationships are often more complex than this. Insects eat more than one kind of plant, and birds eat more than one kind of insect. A diagram that depicts this complex relationship is called a food web. For example:

hazelnut trees → caterpillars
oak trees → caterpillars → warblers
oak trees → beetles → warblers

Organisms that seem completely unrelated can affect each other through a food web in surprising ways. In this example, there is no visible connection between hazelnut trees and beetles, but if the hazelnut trees were all cut down, the beetle population might decrease. It could happen in this way: having no more hazelnut trees to feed on, the caterpillars would begin

Figure III-1. This tree supports populations of lichens, insects, and birds.

eating the oak trees. But that would leave less oak tree food for the beetles, and their population would be lowered.

If one population feeds on another, one might expect that the population that is eaten would die out and disappear. This does happen occasionally. For example, at one time chestnut trees flourished in the United States. They no longer do, because of the invasion of a fungus called chestnut blight, which fed on and destroyed the chestnut trees faster than they could reproduce.

Normally, however, populations that are eaten maintain a balance with populations of eaters by reproducing at a faster rate than they are eaten. Other natural controls also tend to prevent complete extinction of any groups. Thus, the relative sizes of populations in an area remain relatively stable over long periods of time.

OVERVIEW

In Chapter 10, "Building Terrariums," the children plant grass, clover, and mustard seeds. In Chapter 11, "Cricket Populations in the Terrariums," crickets are added. After your students observe these animals eating plants, the term plant-eater is introduced.

Chameleons are added to the terrariums in Chapter 12, "Adding an Animal Eater." Observations of these organisms capturing and eating crickets lead to the introduction of the term animal-eater. The children then identify plant-eaters and animal-eaters shown in a picture. You introduce the terms predator and prey.

The children's experiences with organisms in the terrariums pave the way for Chapter 13, "Reviewing the Food Chain Concept." In Chapter 14, " 'Inventing' the Food Web Concept," you invent the concept and the children construct a food web with humans as the central population.

Finally, in Chapter 15, an outdoor human-centered food web is observed.

GETTING READY

Plan to order the organisms in Shipment P-2 at least three weeks before you plan to begin Chapter 11. You will need the crickets for that chapter and the chameleons for Chapter 12. (See "Schedule of Activities," page 96.) When you mail the order form, record the arrival date you requested. Information on receiving and maintaining organisms is given on page 89.

Looking ahead even further, you will need to order the organisms in Shipment P-3 at least three weeks before you plan to begin Chapter 16. Record on your calendar the arrival date requested for that shipment also.

10 Building Terrariums

SYNOPSIS

Teams establish populations of clover, grass, and mustard plants in terrariums to provide food sources for crickets.

Suggested time: ***one session***

TEACHING MATERIALS

For each of seven teams:

Drawer 3

1 tumbler

Drawer 4

1 six-liter container with lid

Drawer 5

1 package of clover seed
1 package of grass seed
1 package of mustard seed

For the class:

soil‡
paper towels*
colored construction paper*

Drawer 3

3 tumblers

Drawer 5

4 water sprinklers

* provided by the teacher
‡ in Sand and Soil box

NOTE
Maintain the demonstration terrarium you construct in this activity; it will be used to store the chameleons that arrive in Shipment P-2.

ADVANCE PREPARATION

Place labeled tumblers of each kind of seed and other materials at several distribution stations. Use additional tumblers as soil scoops.

TEACHING SUGGESTIONS

The seed-planting and plant-growing in this chapter necessarily precede the exploration activities leading to the plant-eater and animal-eater concepts.

Building terrariums. Remind your pupils that a habitat is where an organism lives, and explain that a terrarium is an artificial habitat for land organisms. Say that they will build terrariums and ask them what conditions are required for organisms that live on land.

Divide the class into seven teams. Then, using one of the 6-liter containers, demonstrate the steps listed on page 46.

Figure 10-1. Planting seeds for a terrarium.

- Add five cups of soil to the container.
- Sprinkle mustard, clover, and grass seeds (about fifty of each kind) over the soil surface. Cover these seeds with a thin layer of soil.
- Gently water the soil until it is thoroughly moist, but not soaked.
- Place a lid on the terrarium.
- On the frosted area of the terrarium, write your initials and the date. Place the terrarium near the light source. (Save it for use in Part Three.)

Now let the teams gather the necessary materials and build the terrariums according to the procedure you have demonstrated. When all the terrariums have been placed near the light source, make sure the light is on. Leave it on continuously unless the temperature of your room exceeds 27°C(80°F).

Soil moisture in the terrariums. The seeds will grow within a wide range of moisture. Show the children how to test the soil for the correct amount of moisture: When a pinch of soil is squeezed, no water should run out; but the soil particles should cling together.

At no time after the initial watering should water stand on the surface of the soil. If a terrarium does become flooded, suggest that the students tip the container so that the excess water runs into one corner. They can then draw up the water with paper towels or a sponge.

Have the children water and observe their terrariums three times a week.

Observing the terrariums. Over the next few science periods, give the students many opportunities to observe their terrariums and to describe what is happening to the plant populations. Most children, even those who have planted seeds before, are excited by the first hint of green emerging from the soil.

Invite the children to try to identify the plants as they appear above the soil. Which kind appeared first? Which last?

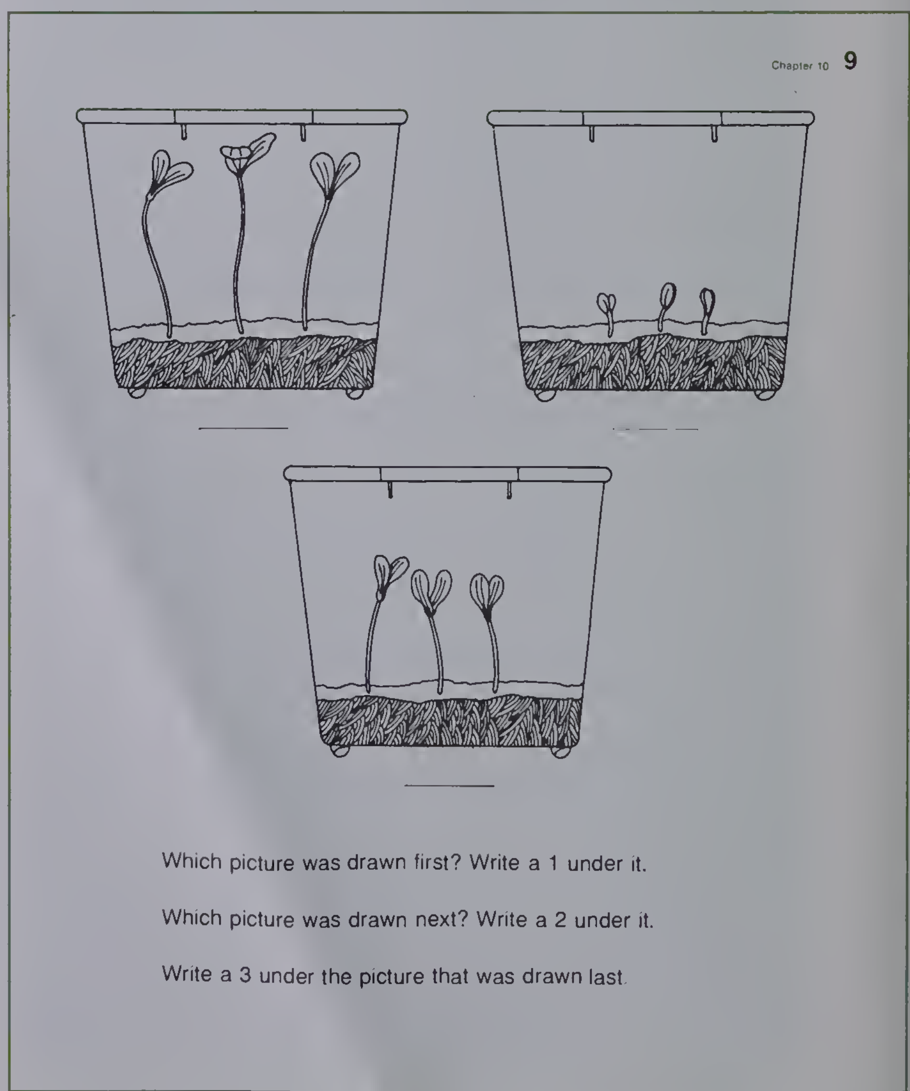
Hold brief class discussions so the children can ask questions and report their observations.

Identifying parts of plants. As the seedlings grow, ask the pupils to point out the parts of a plant—leaves, stem, and roots. Allow some pupils to pull up a few plants to look at the roots.

Using student manual page 9. The three pictures show the same terrarium at different times. They are out of sequence. Ask the children to write a *1* under the picture that was drawn first; *2* under the picture that was drawn next; and *3* under the last picture.

Measuring growing plants. As soon as seeds germinate and shoots are seen above the soil, children can measure and compare the plants' heights. They can make the measurements with rulers and mark them on the container with crayon, or they can cut strips of paper equal to the average heights of the plants. These strips can be glued to the sides of each terrarium. The name of the kind of plant should be written on each strip.

Figure 10-2. Measuring plant height.



11 Cricket Populations in the Terrariums

SYNOPSIS

Crickets are added to the terrariums.

Children observe the effects of the new population on the clover, grass, and mustard populations.

The term **plant-eater** **is introduced.**

Suggested time: ***five or six sessions***

TEACHING MATERIALS

For each of seven teams of children:

terrarium (prepared in Chapter 10)
1 paper towel*
10 crickets†

Drawer 2

2 magnifiers

Drawer 3

1 plastic bag

For the class:

soil‡
tape*
toothpicks*

* provided by the teacher
† in Shipment P-2
‡ in Sand and Soil box

ADVANCE PREPARATION

Receiving organisms. Plan to begin this activity on the day you receive Shipment P-2, which contains crickets and chameleons. See page 92 for information about receiving chameleons.

Distributing crickets. Hand each of seven children a plastic bag.

- Now loosen one end of the cricket shipping container and insert it into a bag held open by the first child. Shake gently until about ten crickets drop into the bag.
- Have the child pinch the top of the bag closed and remove it; have the second child replace the first one immediately, receiving ten more crickets in the second bag.
- Continue in this manner, holding the shipping container still while the children transfer the bags.

Figure 11-1. Distributing crickets.

- Probably no crickets will escape. In fact, to get them all out, you may have to strike the closed end of the container with your hand.
- Have the children put the bags of crickets at distribution stations.
- You provide magnifiers and paper towels at the stations.

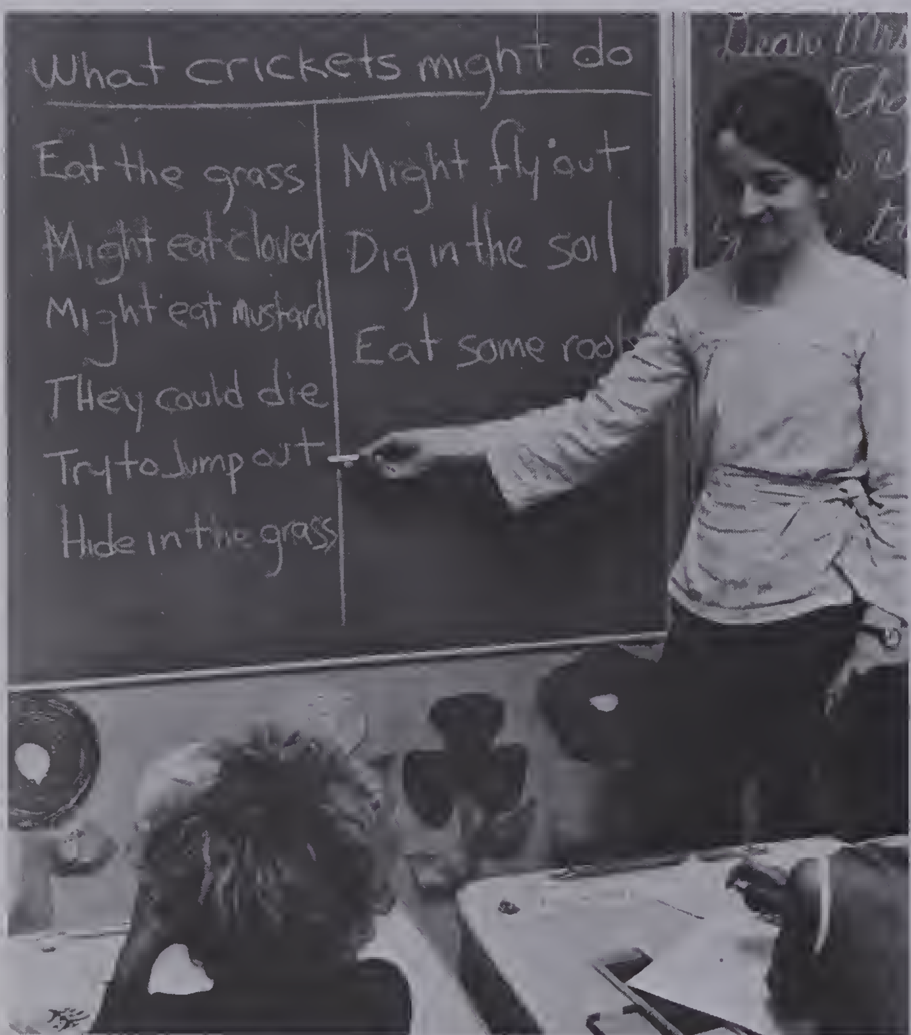
TEACHING SUGGESTIONS

Because your students have probably not observed crickets closely before, the initial part of this activity is exploratory. The introduction of plant-eater constitutes an invention.

Predicting results. Tell the class that they will now add these animals to their terrariums.

- Ask them what the crickets might do when placed in the terrariums, and list their ideas on the chalkboard under the heading "What Crickets Might Do." (The chart may resemble the one in Figure 11-2.)
- Children usually observe events in the terrariums more closely if they have predicted certain outcomes. Later on, when any child observes one of the events predicted by the class, have him or her place a check mark after the prediction on the chalkboard list.
- After several items have been listed, write "Differences in Crickets" on another part of the chalkboard.
- Tell the children to record under that heading any differences they observe among the crickets.

Figure 11-2. Making predictions.



Adding crickets to the terrariums. Permit each team to obtain their terrarium, two magnifiers, a paper towel, and a bag of crickets.

- Tell your pupils to place a crumpled paper towel somewhere in each terrarium to provide a dry area for the crickets. They should replace the towel when it gets wet.
- The children may add crickets either by inverting the plastic bag and shaking the crickets into the terrariums or by gently scooping them out of the bags one at a time.
- The terrarium lid should be replaced as soon as possible after the crickets have been added. Each team should write the date and the number of crickets in the population on the frosted area of the terrarium. (Save the plastic bags for future use.)

Sharing observations. As the children observe the crickets, remind them to check off the predictions of the "What Crickets Might Do" chart as they observe events.

- After the students have observed the crickets, encourage them to report on their observations. You can use comments listed under "What Crickets Might Do" for discussion topics.
- Then let the children describe the differences between crickets. Some will have noticed size, color, and antenna length; others may have noticed a cricket probing the soil with the needlelike structure (ovipositor) extending from the rear of the abdomen.
- Some children may suggest that a cricket is laying eggs. Do not tell them that tiny crickets will hatch from these eggs.
- Encourage the children to gently push a toothpick into the spot where the cricket inserted the ovipositor. The soil around the toothpick should be watered daily to keep the soil moist but not soaked. (Hatching should occur in about three weeks.)

Introducing plant-eater. When students report crickets eating plants, tell them any animal that eats plants is called a *plant-eater*. Write the name on the chalkboard and encourage them to name other plant-eater populations. They might mention daphnias and aphids as well as cows, deer, or other familiar animals.

Figure 11-3. Adding the crickets.

Planning ahead. Begin Chapter 12 within a day or two and teach it concurrently with this chapter.

Identifying male and female. If, after several observation periods, the children have not noticed the two types of adult crickets, invite them to look carefully and try to discover the differences between crickets.

When the children report that some crickets have two rear spines and some three, tell them that the crickets with two spines are male and those with three are female.

Figure 11-4. Only the female cricket *(bottom)* has an ovipositor.

12 Adding an Animal-Eater

SYNOPSIS

The term **animal-eater** *is introduced.*

Children identify plant-eaters and animal-eaters in the Populations picture as a discovery activity.

You introduce the terms **predator** *and* **prey.**

Suggested time: ***three sessions***

TEACHING MATERIALS

For each team:

terrarium (prepared in Chapter 10)
1 chameleon†

Drawer 3

12 twistems
12 plastic bags

For the class:

Drawer 1

1 large Populations picture

Drawer 5

4 water sprinklers

† in Shipment P-2

ADVANCE PREPARATION

Receiving chameleons. When the chameleons arrive, first place a crumpled paper towel in the demonstration terrarium you prepared in Chapter 10. Then remove the seal from the shipping container, empty the chameleons and moss into the terrarium, and quickly secure the lid. Use a water sprinkler to spray water on the inside walls of the container. Add water frequently, as it is the chameleons' only source of moisture. The chameleons will not require any food before they are introduced to the terrariums. Keep the chameleons in your terrarium out of the children's sight for about one week.

On the day that you introduce the chameleons in class, place one in each of seven bags. To do this, grasp the animal by the base of the tail (not the tip!) and drop it into the bag. Show the students how to do this, also.

Use twistems to keep the bags closed until you have distributed them.

Figure 12-1. The proper way to pick up a chameleon.

TEACHING SUGGESTIONS

This chapter includes exploration, invention, and discovery. Observations of the chameleon are exploratory; the introduction of the concepts animal-eater, predator, and prey are inventions; looking for animal-eaters and plant-eaters on the Populations picture is a discovery activity.

Predicting results. Display a plastic bag containing a chameleon and tell the children the animal's name. You might write the word on the chalkboard as you pronounce it.

Ask the pupils what they think will happen when the chameleon is added to the terrarium. They might suggest that the chameleon will hide, chase crickets, or eat plants. Record the pupils' responses on the chalkboard.

Figure 12-2. Distributing chameleons.

Figure 12-3. Adding an animal-eater to a terrarium.

Observing chameleons. After the teams have obtained their terrariums, give each team a bag containing a chameleon.

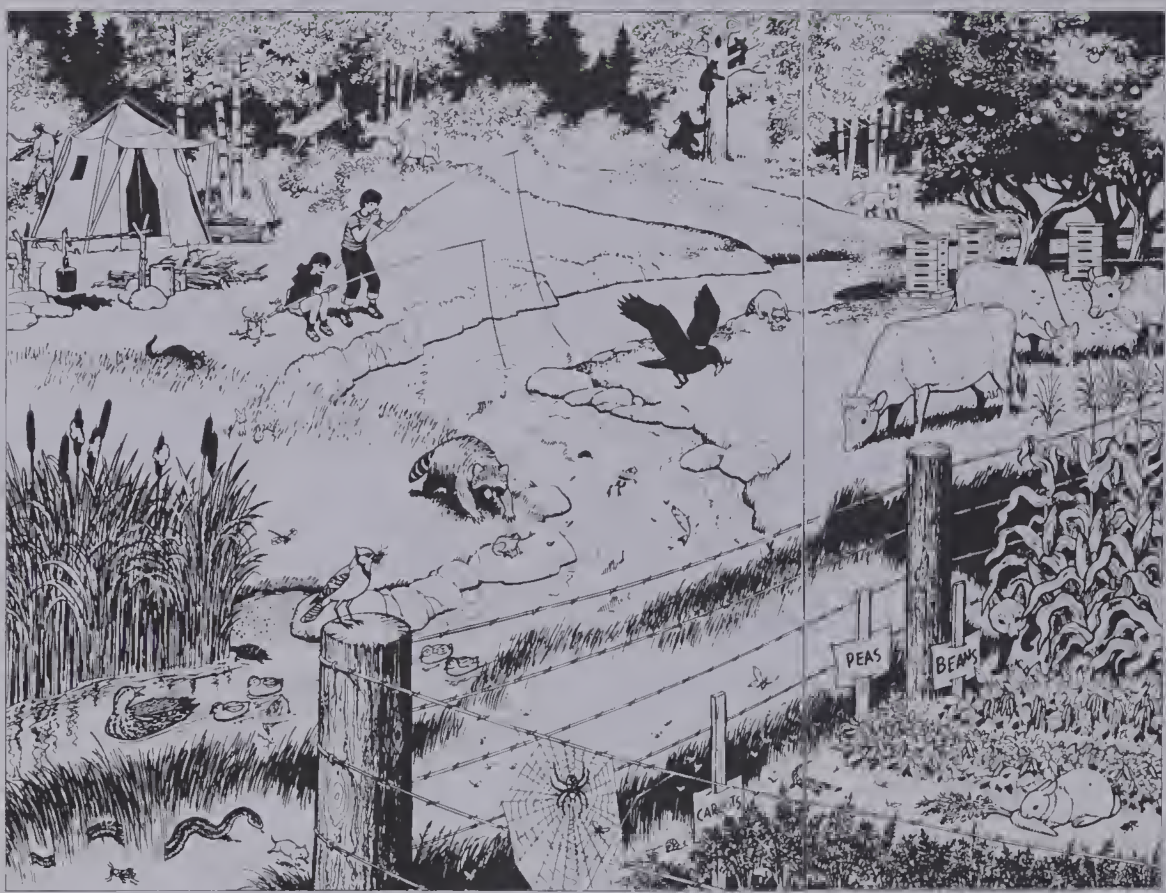
- A team member can either lift the chameleon from the bag and place it in the terrarium or invert the bag over the terrarium. The lid should be replaced as soon as the chameleon is inside.
- Chameleons obtain the water they need from drops of water on plants or on the terrarium walls, rather than from a water dish.
- Have the teams sprinkle water on the inside walls of their terrariums daily to provide the moisture for the chameleons. On Fridays, make sure that the walls are generously covered with drops of water that will last through the weekend.
- Allow enough time for the children to observe what happens after the chameleons are put in the terrariums.
- A chameleon may be observed catching and eating a cricket. It is possible, however, that it will take a day or two before the chameleons become sufficiently adjusted to the habitat to eat.
- Schedule several short observation and discussion periods over the next few days.
- Wait until the children report evidence of chameleons eating crickets before you introduce the term animal-eater.

Introducing *animal-eater*. After the children have observed chameleons eating, gather them for a discussion.

- Review the term plant-eater by asking the students to name the plant-eaters in their terrariums.
- Then tell the children that any animal that eats other animals is called an *animal-eater.*
- Write the name on the chalkboard and ask the class whether there are any animal-eaters in the terrariums.
- If no one mentions the chameleons, you should do so.

Figure 12-4. A completed terrarium setup.

10 Chapter 12



Chapter 12 11

Put an orange X on each animal-eater in the picture.

Draw a green circle around each plant-eater.

Predators

Prey

(continued on page 12)

Discovering plant-eaters and animal-eaters. Post the large Populations picture where all of the children can see it.

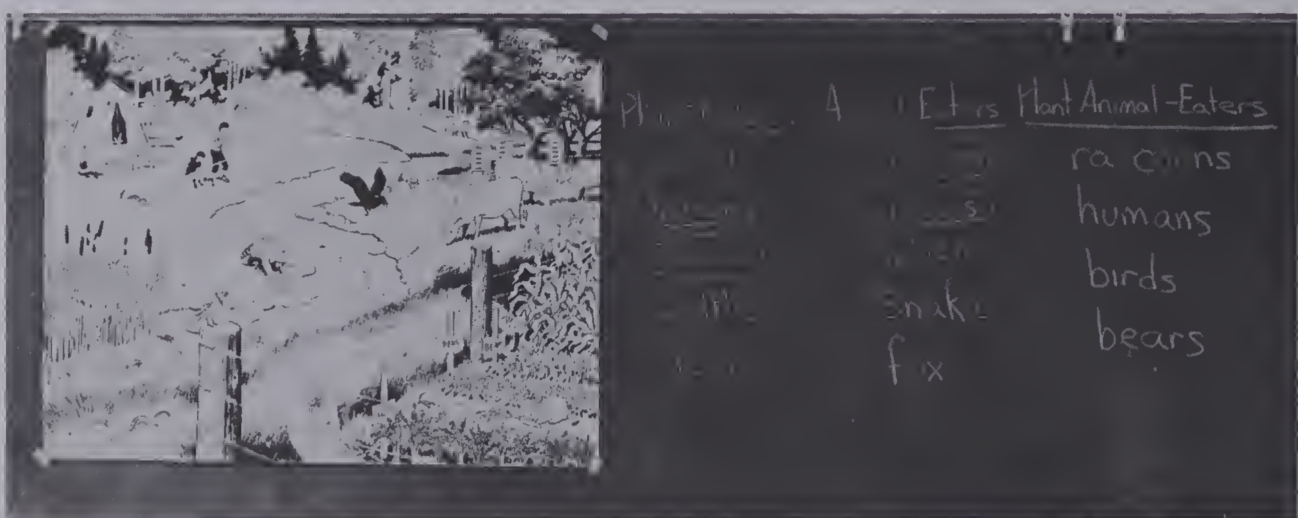
Using student manual pages 10 and 11. Ask the students to open their student manuals to page 10.

- Encourage them to examine the picture for animals eating.
- Then write the headings "Plant-eaters" and "Animal-eaters" on the chalkboard.
- As the children name the animals, ask them to tell you under which heading to list them. Have the students X and circle the animal-eaters and plant-eaters as directed on page 11.

Introducing *plant-animal-eaters.* Ask the students if there are any animals that are listed in both columns.

- Draw circles around the names of animals they

Figure 12-5. "Inventing" *plant-animal eaters*.



suggest, and tell them that an animal that eats both plants and animals is a *plant-animal-eater.*

- Add a new heading "Plant-Animal-Eaters" to the board.
- Write the circled names in the new column and cross them out in the other columns.
- Then ask the children if they can find any other animals in the picture that belong to this category.

Introducing *predator* and *prey*. On another day, invite the children to describe how the chameleon captured the cricket.

- Then explain that an animal that catches and eats another animal is called a *predator* and the animal that is caught is called the *prey*.
- The children should be able to identify the chameleon as the predator and the cricket as the prey.
- Encourage the students to name other examples of predators and prey that are shown in the Populations picture or can be recalled from their own experiences.
- List these on the chalkboard under the headings "Predator" and "Prey."
- Can any animals be listed in both groups?

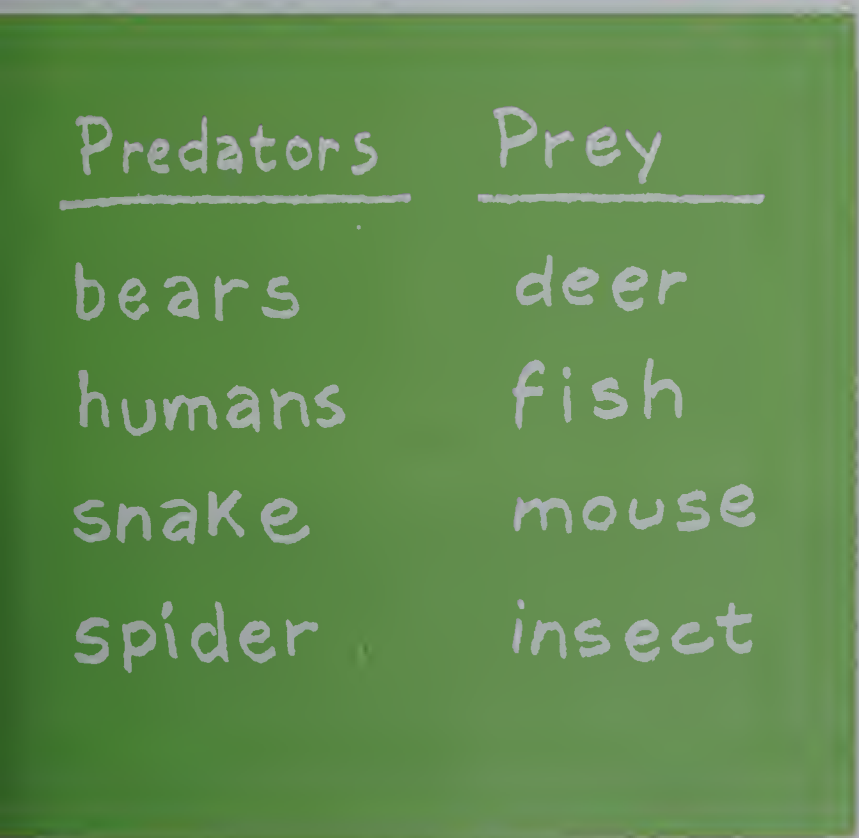


Figure 12-6. Some predator-prey relationships.

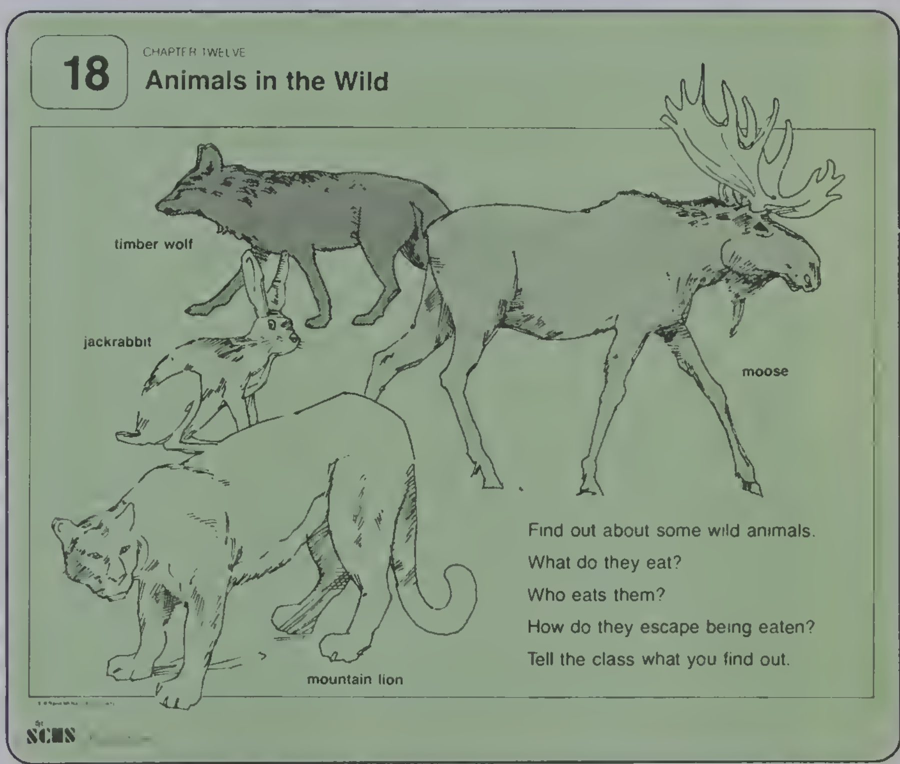
Using student manual page 11. Ask the pupils to write the names of predators and prey under the headings.

- Invite the teams to report which animals in the terrariums are still alive.
- They will probably mention the chameleon and a few crickets.
- Invite the children to describe or speculate about how these crickets escaped being eaten by the chameleon.
- Then ask them to describe ways in which various prey in the Populations picture might escape. For example, the deer might run away from the bears; or the frog might jump into the pond away from the raccoon.

Maintaining the terrariums. The terrariums should be maintained until the students observe young crickets (approximately three weeks after crickets were introduced). When the supply of crickets is exhausted, live flies, mealworms, or other small insects will be needed to feed the chameleons. (Mealworms can be purchased at most pet stores or obtained from a teacher of *Life Cycles* or *Environments*.)

EXTENDING YOUR EXPERIENCE CARD

18. Animals in the Wild. This activity should help the student to relate classroom experiences to the natural world. An encyclopedia or children's natural-history books will be needed.



13 Reviewing the Food Chain Concept

SYNOPSIS

Children record food chains they see in the** Populations **picture.

Suggested time: ***one session***

TEACHING MATERIALS

For each team:

terrarium

TEACHING SUGGESTIONS

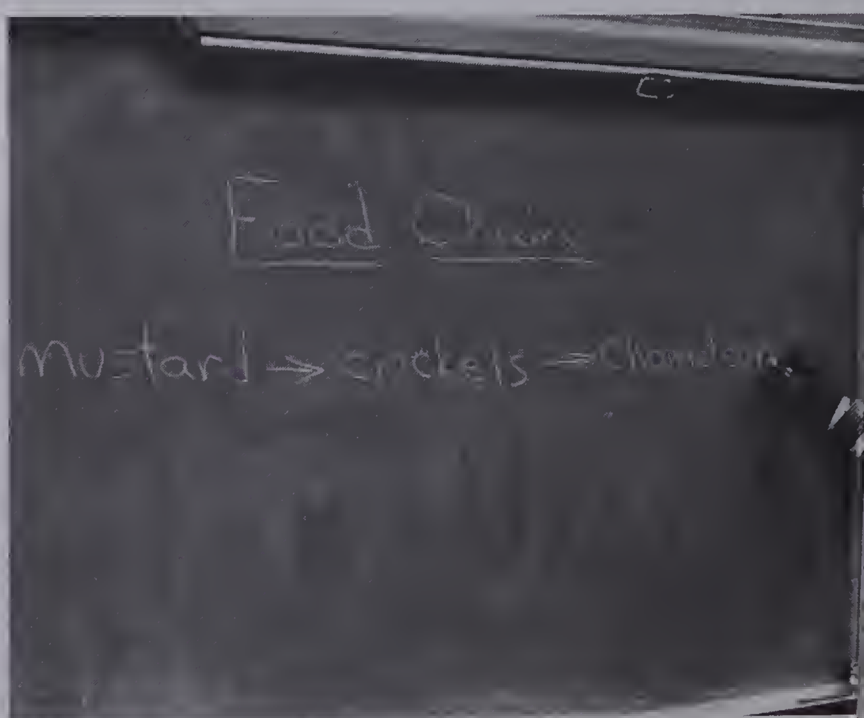
Because the food chain concept was introduced in the *Organisms* unit, this is a discovery activity.

Reviewing *food chain*. Have the children obtain their terrariums and look for any changes in them. After the observation, ask the teams to return their terrariums to the storage area and then gather the students for a discussion.

- Write the word "chameleon" on the chalkboard and encourage the students to tell what they have seen chameleons eat.
- They may name crickets or insects.
- Write the word "crickets" (or other insect) to the left of the word "chameleon."
- Ask what crickets eat and write the name of that population to the left of "crickets."
- Draw an arrow from the plant population that crickets eat to the word "crickets" and say that this stands for "eaten by."
- Then draw another arrow from "crickets" to "chameleons" and state that the crickets are "eaten by" the chameleons.
- Remind the class that this diagram is called a *food chain*. Explain that it is a quick way of showing feeding relationships among populations.
- Invite the pupils to name some other food chains in the terrariums while you write them on the board.
- Some food chains that might be suggested by the children are:

  mustard $\longrightarrow$ crickets $\longrightarrow$ chameleons
  grass $\longrightarrow$ crickets $\longrightarrow$ chameleons
  clover $\longrightarrow$ crickets $\longrightarrow$ chameleons

Figure 13-1. Diagraming a food chain.



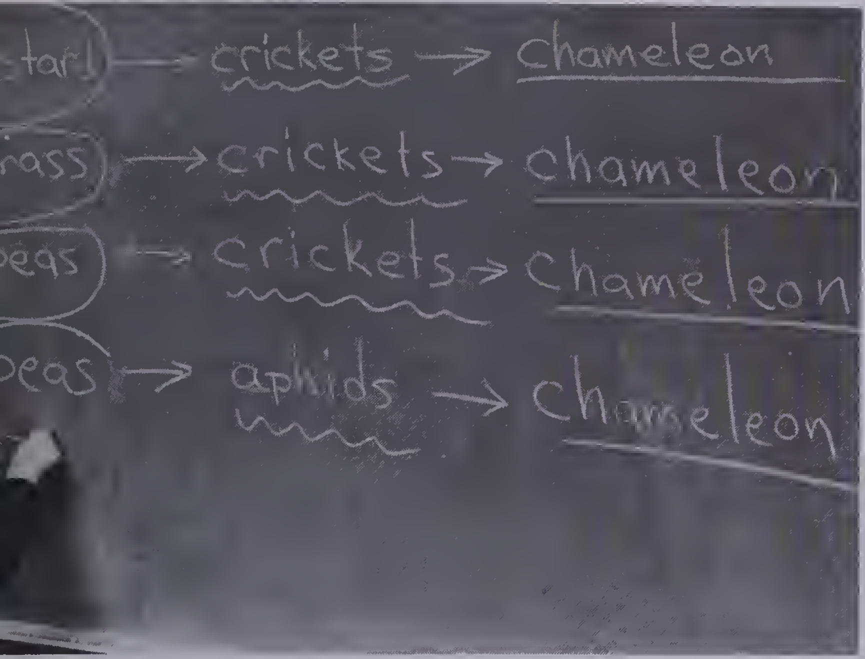


Figure 13-2. Looking at the parts of a food chain.

- Invite a child to come to the chalkboard and draw a straight line beneath the name of each animal-eater population.
- Ask another child to draw wavy lines beneath all the plant-eaters.
- Finally, have a third child circle the plants.
- Ask your students what all the food chains have in common.
- Most of them should recognize that all chains start with plants and that most food chains contain a plant, a plant-eater, and an animal-eater.
- Invite the children to give examples of food chains in nature.
- If a student suggests only a part of a food chain, such as mice ⟶ cats, ask what the mice eat. Or, if given corn ⟶ mice, ask what animals eat mice.

Using student manual pages 10–12. Ask the children to open their manuals to page 10. Suggest that the students find as many food chains in the pictures as they can, and to record them on page 12. You might write a sample on the chalkboard for your students before they begin.

As the children record food chains, remind them to include a plant in each chain. When they have finished, the pupils might be interested in identifying the shortest and longest chains they found.

Cleanup. Although you will not need the terrariums again for activities, you should maintain them until the children have been able to observe the young crickets.

When the terrariums are dismantled, you may give the organisms to the students or other teachers, or dispose of them. Wash the containers with water, air dry or dry with a soft rag, and return them to the kit.

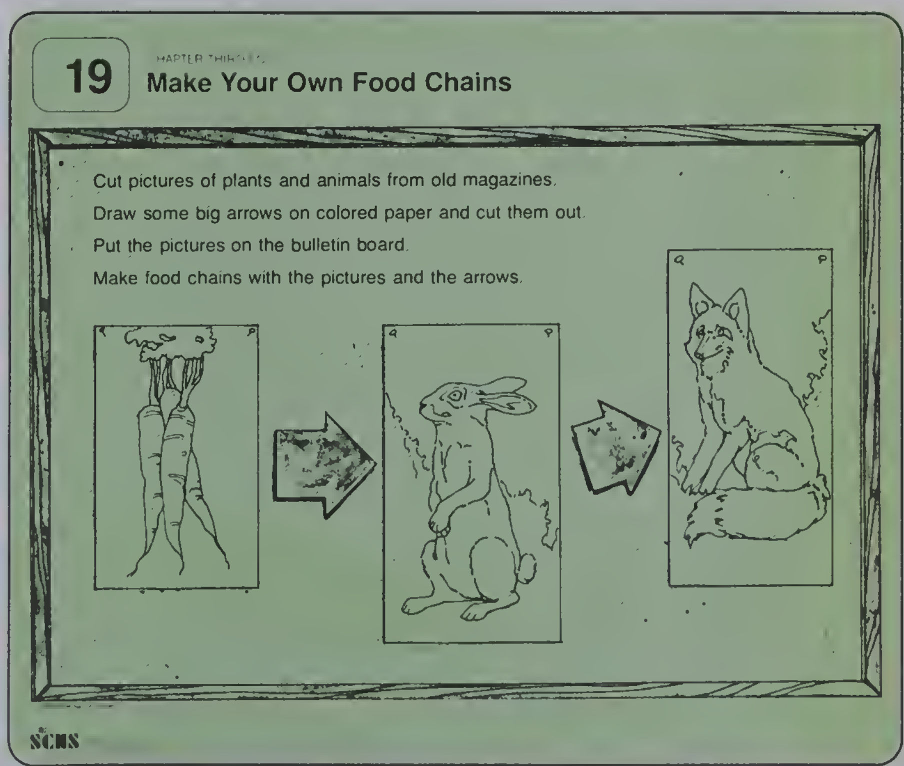

12 Chapter 13

Food chains

Food webs

EXTENDING YOUR EXPERIENCE CARD

19. Make Your Own Food Chains. This is a discovery activity to reinforce the food chain concept. The child will need old magazines, such as *National Geographic* and *Natural History*, construction paper, and scissors.



14 "Inventing" the Food Web Concept

SYNOPSIS

The food web concept is introduced.

Children then construct a food web for organisms in the Populations picture.

Children also make a food web with humans as the central population.

Suggested time: *two sessions*

TEACHING MATERIALS

For each child:

crayon or pencil*

* provided by the teacher

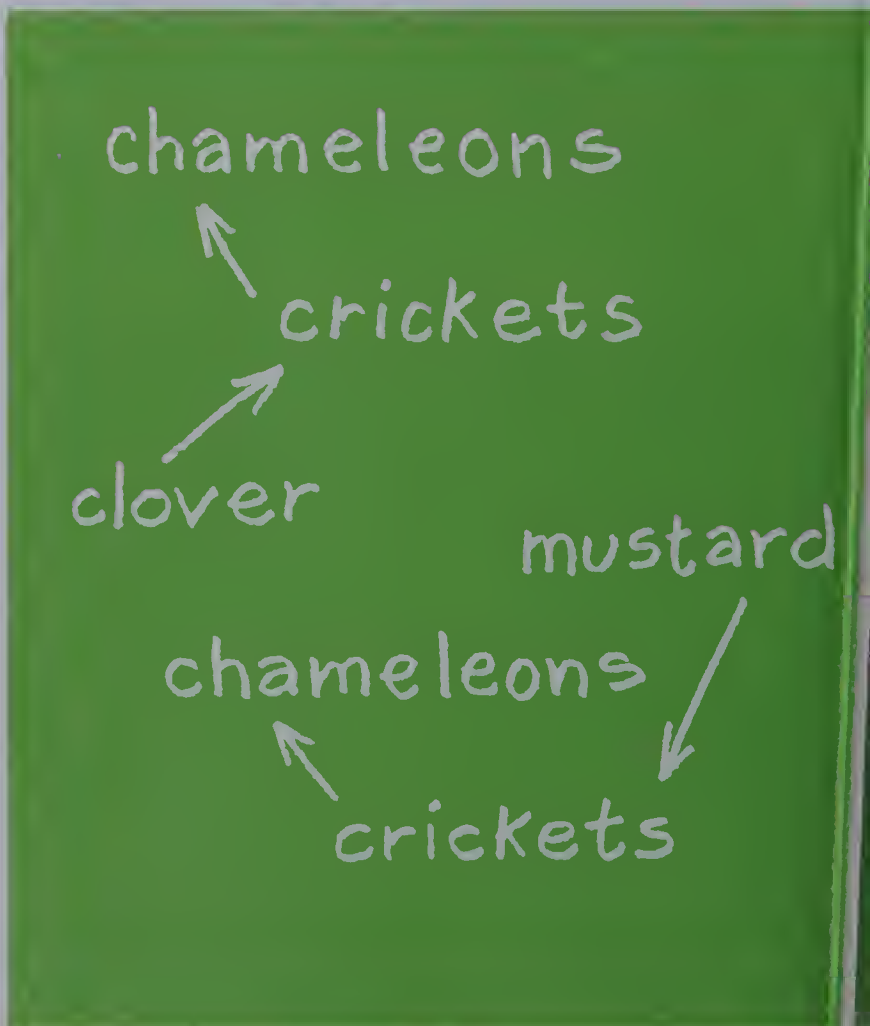
TEACHING SUGGESTIONS

This activity includes invention of the food web concept.

Inventing food web. Write the words chameleons, crickets, clover, mustard, chameleons, and crickets on the chalkboard.

- Ask the children how you should connect the populations with arrows to make two food chains.
- The resulting diagram may look similar to Figure 14-1.
- Now ask the students to name the populations that are included in both food chains.
- When they identify crickets and chameleons, erase one of each of these population names and redirect the arrows to the remaining ones as shown in Figure 14-2.
- Tell the class that when two or more food chains are connected to each other, the result is called a *food web*.
- Request the children to name other organisms they had in their terrariums and add these to the web.
- Each time a population is added, students should suggest how to connect it to the population that either eats it or is eaten by it.

Figure 14-1. Related food chains.



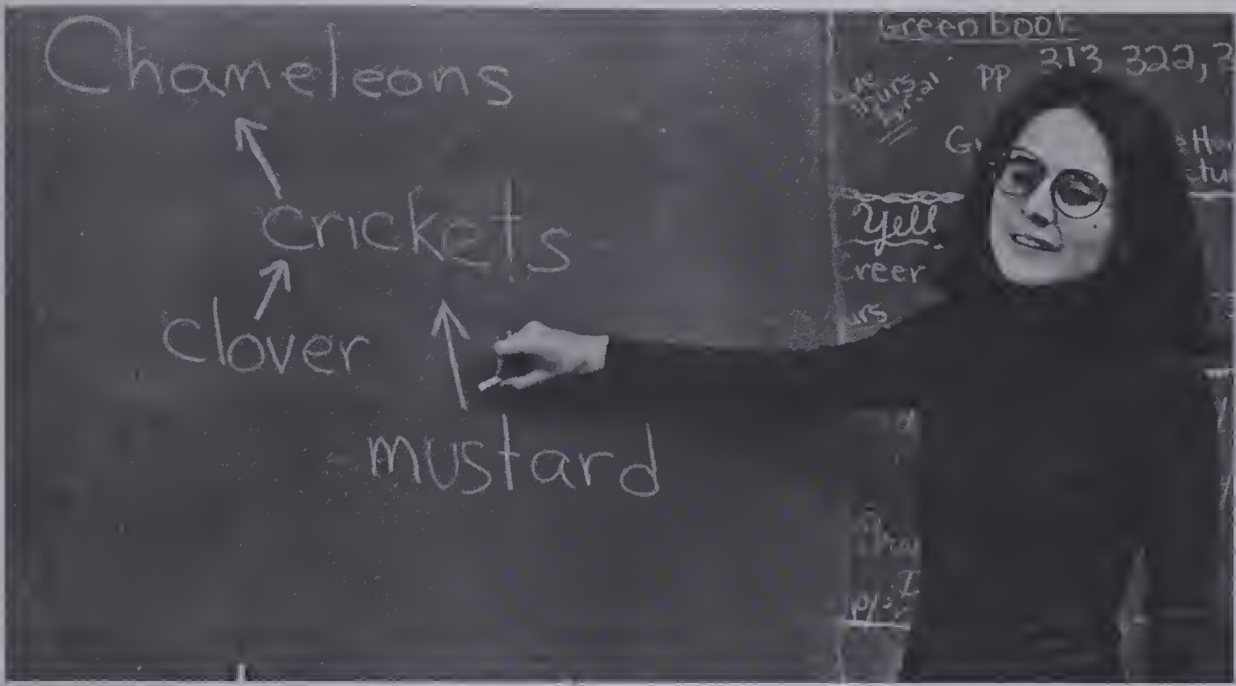


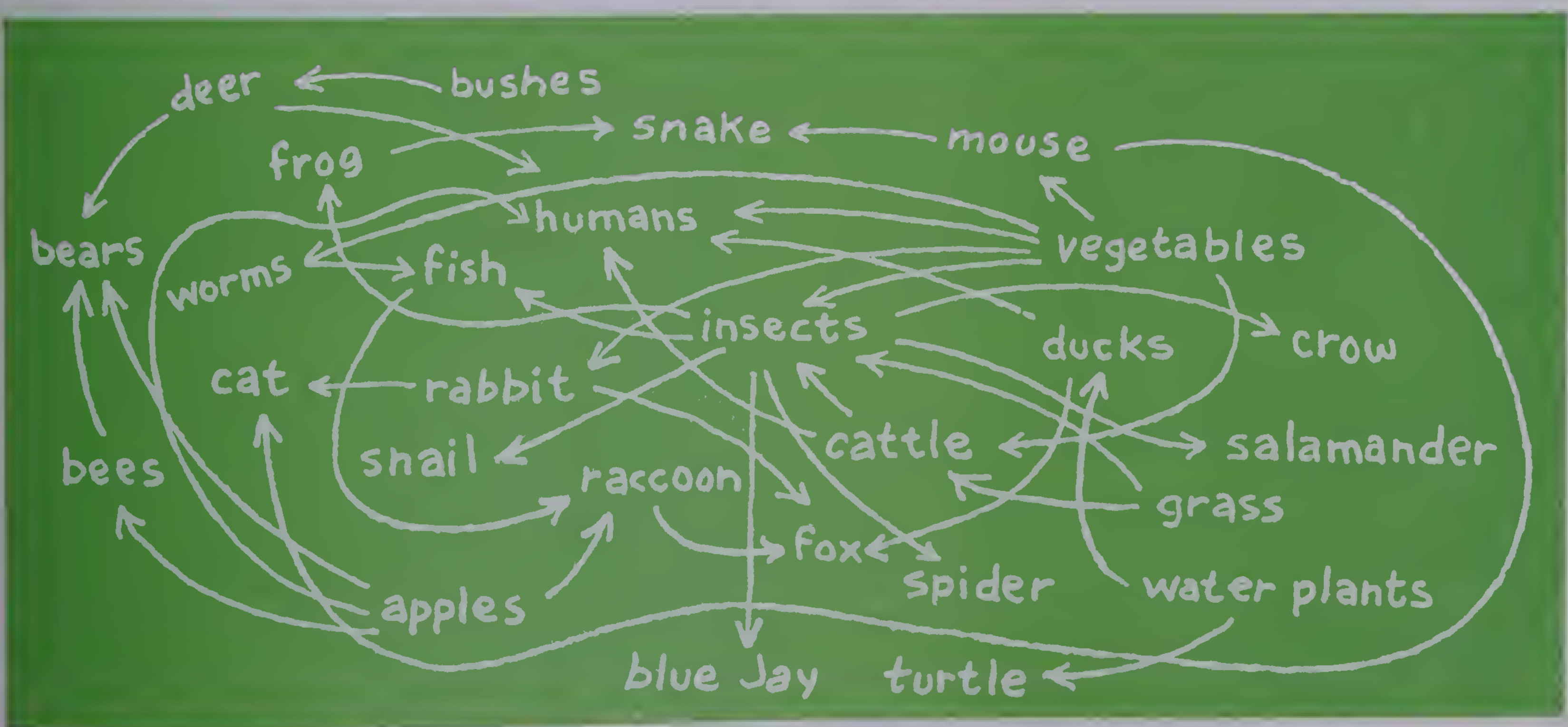
Figure 14-2. Combining related chains to make a food web.

Using student manual pages 10–12. Invite pupils to make the largest possible food web from the populations shown in the picture. Have the children record their food webs on page 12 of the student manual. How they connect the populations in their drawings will provide you with feedback about their understanding of the food web concept.

Human food webs. During another class period, write the word "humans" in the center of the chalkboard and circle it. Tell the children that they will make a food web with humans as the central population.

- Then draw two larger circles around the word "humans," one with a radius of about 25 cm (10 in) and the second about 50 cm (20 in).
- Explain that the animal populations will be written on the inner circle and the plant populations on the outer circle.
- If some of the children suggest spaghetti dinner, stew, or some other combination of plants and animals, ask them to try to determine what plants and animals the food is made from (e.g., stew is made from cattle, potatoes, carrots, and onions).
- As you write the plant and animal populations on the board, have the students tell you how to draw the arrows to represent the food relationships.

Figure 14-3. A food web diagram for the Populations picture.



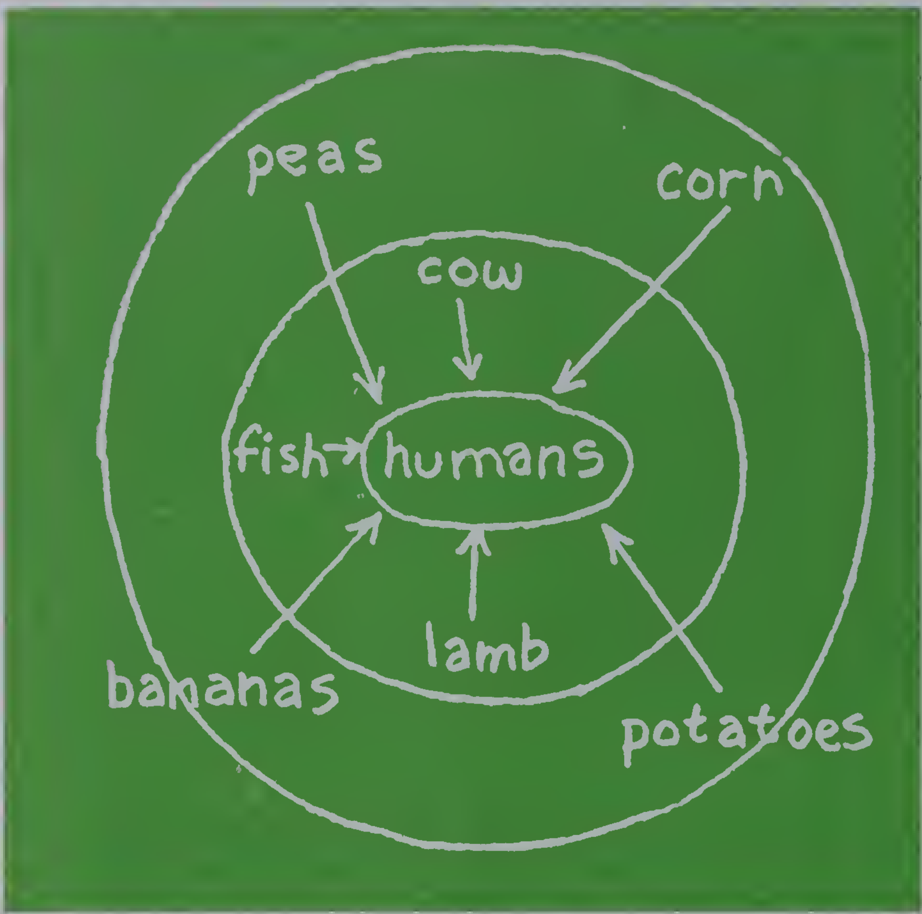


Figure 14-4. Beginning a human food web.

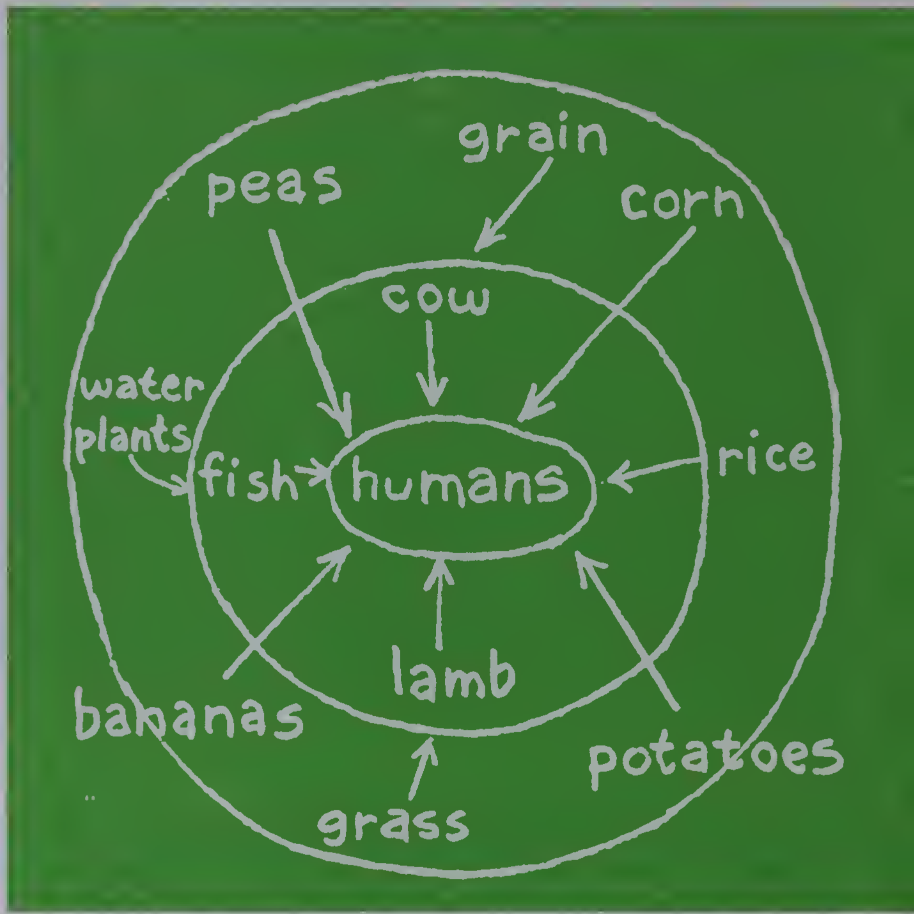


Figure 14-5. Completing the human food web.

- At this point, the diagram may resemble the one illustrated in Figure 14–4.
- Ask what the animal populations in the diagram eat.
- Add the populations the children suggest and the appropriate arrows.
- Be certain that the children have included food for all animal populations in the diagram.
- You now have a complete food web, which may resemble the one in Figure 14–5.

Discussion. To help students realize the importance of plant populations as a human food supply, block out the animals in the food web (sweep your hand across the animal zone) and ask a question such as "Could humans survive if there were no animal populations?" Some children will argue that animals are a necessary part of the human diet, but others may realize that humans can live on plants alone.

Now ask the students if they think humans could survive if there were only animal populations and no plants. The children should realize that there would be no food for animals and, so, no food for humans.

OPTIONAL ACTIVITY

Parts of plants. Some children do not realize that when we eat such foods as corn, cabbage, or celery, we are in fact eating only part of the plant. To illustrate that we eat different parts of the plants, display some real or pictured plants. Examples are: lettuce or cabbage (leaves), carrot or radish (roots), asparagus (stems), orange, tomato, apple (fruits), and walnuts or corn (seeds).

If possible, provide a picture of the whole plant (such as a carrot with the greens at the top) or show the class a plant.

15 Populations That Live with Humans

SYNOPSIS

Children record plant and animal populations in and around their homes and school.

They infer that many populations could not survive if humans were to disappear from the area.

Suggested time: ***one session***

TEACHING MATERIALS

For the class:

chart paper*

* provided by the teacher

BACKGROUND INFORMATION

Places where humans live—from small villages to densely populated cities—contain many plant and animal populations in addition to the human population. Many populations are there because of humans; a few survive in spite of human activities.

When we realize how much urban areas are dominated by humans, we see many organisms in a new light. Most city plants are introduced into an area by humans—sometimes accidentally, sometimes by design. The most obvious plants in a city are trees that have been selected because they offer the best combination of characteristics important to us, such as hardness and shade. Often these trees must also be able to survive with little water because so much of the area around them is paved. And they must be resistant to the pollution that we create. Trees provide food and shelter for many kinds of animals. Insects eat the leaves or burrow into the bark. Birds feed on the insects, and both birds and squirrels eat the fruits.

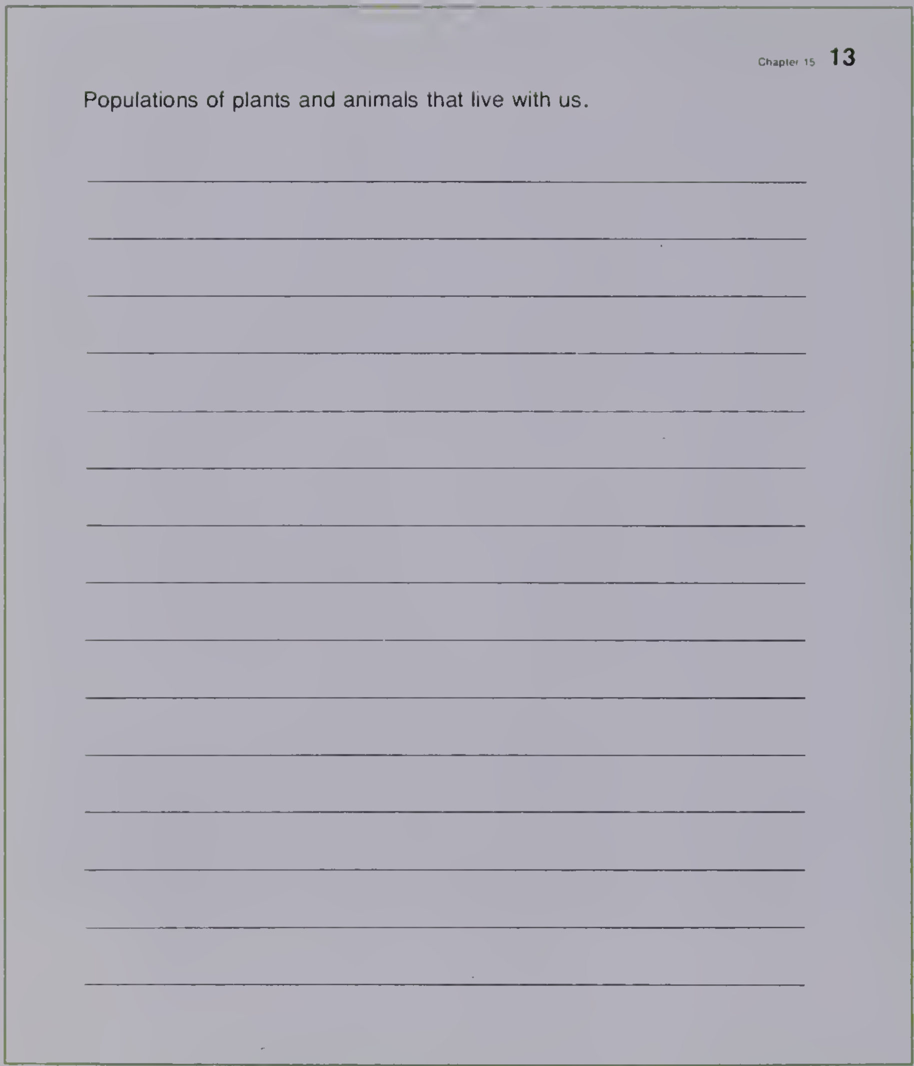
Parks and building sites are landscaped with a wide variety of shrubs and smaller plants that harbor many kinds of insects. The soil beneath the shrubs, lawns, and along walls is often populated with animals such as insects, worms, and sow bugs. And in alleys and vacant lots, weeds and wild flowers shelter other small insects.

One interesting aspect of an area dominated by humans is the large variety of uninvited populations which find an easier life near us, or near our dogs and cats. If organisms compete with humans for food and shelter, or if they threaten human health, they are considered harmful and are called pests. Rats, mice, roaches, and flies are among these unwelcome organisms. They populate areas where food is stored, prepared, or served and where garbage is dumped. Buildings and trash heaps provide places where animals can dwell. Other animals such as rabbits, pigeons, and squirrels are usually tolerated by humans although they may at times raid our gardens or spread diseases. We may welcome some wild plants if they are decorative or at least not a nuisance, but most of us draw the line at ragweed or quack grass.

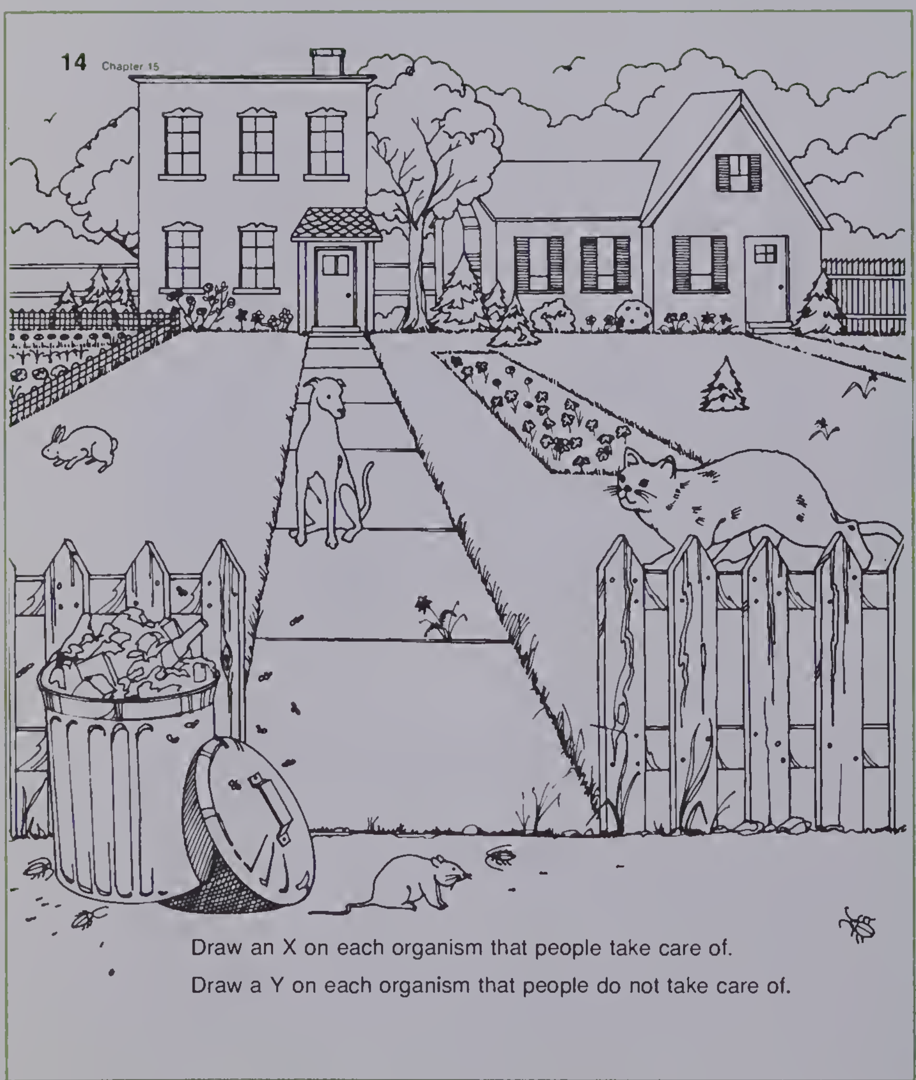
TEACHING SUGGESTIONS

In this discovery activity your pupils relate their understanding of populations to their local areas.

Using student manual page 13. Encourage the children to make individual lists of the animal and plant populations that live in the same area with them. Trips outside the classroom may be taken, but most children will be able to recall populations they have seen in and around the home and on the way to and from school.


Chapter 15 13

Populations of plants and animals that live with us.



- Ask the children to include in their list any populations of animals or plants they have had in the classroom or seen on field trips.
- Ask one child to read the list recorded in his or her student manual.
- Write the list on the chalkboard.
- Then ask other pupils to name some other plants and animals. Add these to the chalkboard record.
- After recording the populations on the chalkboard, tell the students that the human population is the dominant one, because humans directly affect the lives of other populations by providing food and/or places to live.
- Encourage the students to name plant and animal populations on the list that people deliberately care for. These might include dogs, cats, horses, trees, cows, flowers, goldfish, and corn.
- Draw a line under each population as it is named.
- Then ask the students to name the plant and animal populations that humans do not intentionally care for. These might include rats, pigeons, squirrels, cockroaches, mosquitoes, flies, dandelions, aphids, and thistles.
- Circle each population as it is named.

Using student manual page 14. The drawing is of an urban area showing plants and animals, some of which humans care for and some of which they do not. Read the directions to the children.

Figure 15-1. Classifying populations that live near humans.

Discussion. Point to one of the animal populations you underlined on the chalkboard. Ask the children what might happen to this population if all the humans vanished. Where would the animals live? Where would they obtain their food?

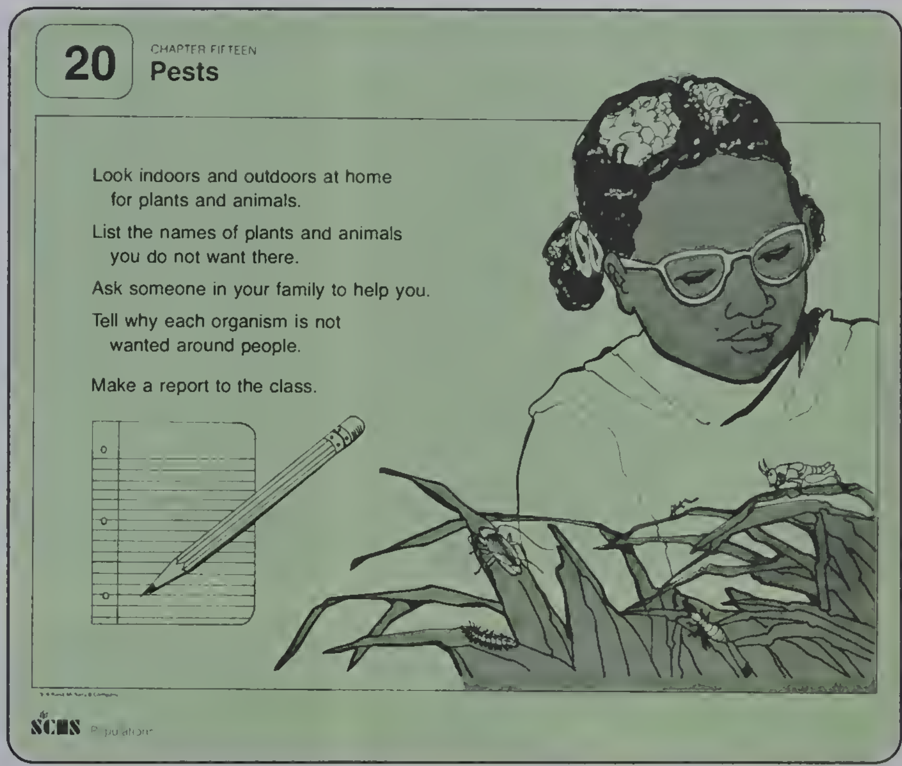
- Ask the same question about several other animal populations you underlined.
- Now ask what would happen to the underlined plant populations if humans disappeared.
- The children should infer that without human care some of the populations might not survive.
- Indicate some of the circled plant and animal populations that humans support indirectly.
- Ask, "If there were no garbage, what would rats eat? What would happen to the aphids if there were no gardens?"
- Continue raising similar questions, encouraging the discussion until the students realize that the living conditions of all plants and animals would be changed drastically and many of them would probably not survive.

A classroom mural. Suggest that the children construct a mural of their town showing the plant and animal populations—including humans—listed on the board. They may either make drawings of the organisms or cut out pictures from magazines.

Arrows can be used to show food webs, and strips of colored paper to indicate such things as "shelters," "gives food to," or "carries seeds of."

EXTENDING YOUR EXPERIENCE CARDS

20. Pests. By discovering weeds in lawns or gardens, and insects or other pests in and around home, the children will have a concrete experience about the relation of some plant and animal populations to human populations.



Extending Your Experience cards 1–20 are now available for the children's use. For materials needed, refer to the equipment list accompanying the set of cards.

CONCEPT / PROCESS EVALUATION

If you choose to evaluate the children's understanding of the concept of feeding relationships, turn to page 79 of the evaluation section at the back of the guide.

Part Four

Populations in Water

OBJECTIVES

To describe feeding interactions among aquatic populations.

BACKGROUND INFORMATION

Populations of plants and animals that live in ponds, streams, lakes, or oceans interact in much the same way as terrestrial populations. As with land populations a fundamental interaction of aquatic populations involves food. Aquatic plants (mostly algae) initially produce food that supports the animal populations. Plant-eaters (many of them crustaceans, such as daphnias or brine shrimp) feed on aquatic plants. Animal-eaters (mostly fish) feed on plant-eaters. They, in turn, may be eaten by larger fish, or by mammals. When humans eat fish, they become a part of the aquatic food web.

OVERVIEW

In Chapter 16, children build aquariums containing hornwort, *Wolffia,* and snails. They add damselfly nymphs (larvae) to the aquariums in Chapter 17 and observe the interactions for several days. In Chapter 18, the children set up experiments to discover the food relationships in the aquariums.

Figure IV-1. A community of aquatic populations.

16 Building Aquariums

SYNOPSIS

Teams of children set up aquariums containing algae, hornwort, **Wolffia***, and snail populations.*

Suggested time: *one session, followed by several days' observation*

TEACHING MATERIALS

For each team of four children:

Drawer 2

2 magnifiers

Drawer 6

1 fluted container

For the class:

hornwort†
Wolffia†
daphnias†
snails†
damselfly nymphs†
algae†
sand‡
paper towels*
felt pen or grease pencil*

Drawer 2

light source

Drawer 3

1 pipe cleaner
3 plastic tumblers

Drawer 6

4 fluted containers
1 dip net

* provided by the teacher
† in Shipment P-3
‡ in Sand and Soil box

ADVANCE PREPARATION

Aging tap water. At least two days before you expect Shipment P-3, rinse twelve fluted containers (do not use cleaning compounds) and add water to each until it is three-quarters full. Eight of the containers are for use as aquariums; three are for the damselfly nymphs, daphnias, and snails; and one is for use as a source of aged tap water. (Keep a supply of aged tap water on hand to replenish water that evaporates from the aquariums.)

Receiving organisms. You will receive hornwort, algae, snails, *Wolffia,* daphnias, and damselfly nymphs in Shipment P-3.

- When you receive the daphnias, pour the contents of the shipping container into a fine dip net, discarding the liquid.
- Then turn the dip net inside out, submerge it in the algae water that you have prepared, and wash the daphnias from the net.
- Place the daphnia container near a light source, but not too near; the animals can easily become too hot. The optimum temperature is 20–25°C (65–80°F). Above or below this temperature range, the animals will die or they will produce resistant egg cases rather than living young.
- Distribute the *Wolffia* among three tumblers, each three-quarters filled with aged tap water.
- When you receive the damselfly nymphs, pour the contents of the shipping container into a container of aged tap water.
- Check to see if all the nymphs are alive by touching them with a pipe cleaner. Those that don't move are dead and should be removed.
- Add several sprigs of hornwort to the container. The nymphs do not require any food before the children add them to the aquariums in Chapter 17.
- When you receive the snails, place them in another of the containers of *aged* tap water. (Though their shells may make them appear hardy, snails are sensitive to acidity and small amounts of certain compounds in tap water.)
- If plants are shipped with the snails, transfer them to the same container in which you put the snails.
- Plan to begin this chapter upon arrival of the shipment. If you expect a delay of more than two days, follow the information in "SCIIS Plants and Animals," page 90, to maintain hornwort and *Wolffia.*

Preparing aquariums. Sand for the aquariums should be rinsed to remove the powder that results from abrasion during shipping. To do this, place about three cups of sand in an empty container, fill the container with tap water, stir sand and water together, and pour off the water along with debris from the sand. Repeat

several times until the water clears a few seconds after stirring. Rinse enough sand to put about one cup into each of the eight containers of aged tap water that are to be used as aquariums.

After you have set up the containers for daphnias and damselflies (as described below), divide the remaining algae among the eight aquariums.

TEACHING SUGGESTIONS

Because many of your pupils built aquariums and observed aquarium events in *Organisms,* this is a discovery activity for several concepts.

Setting up the aquariums. Tell your pupils that they are going to set up aquariums. Explain that the natural habitat for the populations that they will work with is a pond or stream, and that an aquarium is a substitute habitat. Encourage the children to name some aquatic animals and plants they have seen.

Figure 16-1. Transferring *Wolffia*.

- Divide the class into eight teams and give each team a container with sand and algae water.
- Point out the containers of *Wolffia* and hornwort, and identify these organisms.
- Write the names on the chalkboard.
- Have each team add two sprigs of hornwort, three snails, and some *Wolffia* to their aquarium. (A member of each team can dip a finger into the *Wolffia* container; the plants will stick to the finger and can be transferred to the aquarium.)
- Have each team of children label their aquarium with an identifying letter or numeral.

Using student manual page 15. Encourage the children to record the names and numbers of organisms in each population in their aquariums. (The number of *Wolffia* can be estimated.)

Tell the children that it is important to maintain the water levels in the aquariums. Have them mark the original water levels on the sides of the aquariums with felt pens or grease pencils.

Chapter 16 15

Animals in my aquarium.

Kind of animal	Number added	Number remaining

Storing aquariums. Put the aquariums near the light source, which should remain on at all times, unless the air temperature in the classroom exceeds 25°C (80°F). Have the children check the water levels daily and add aged tap water as necessary.

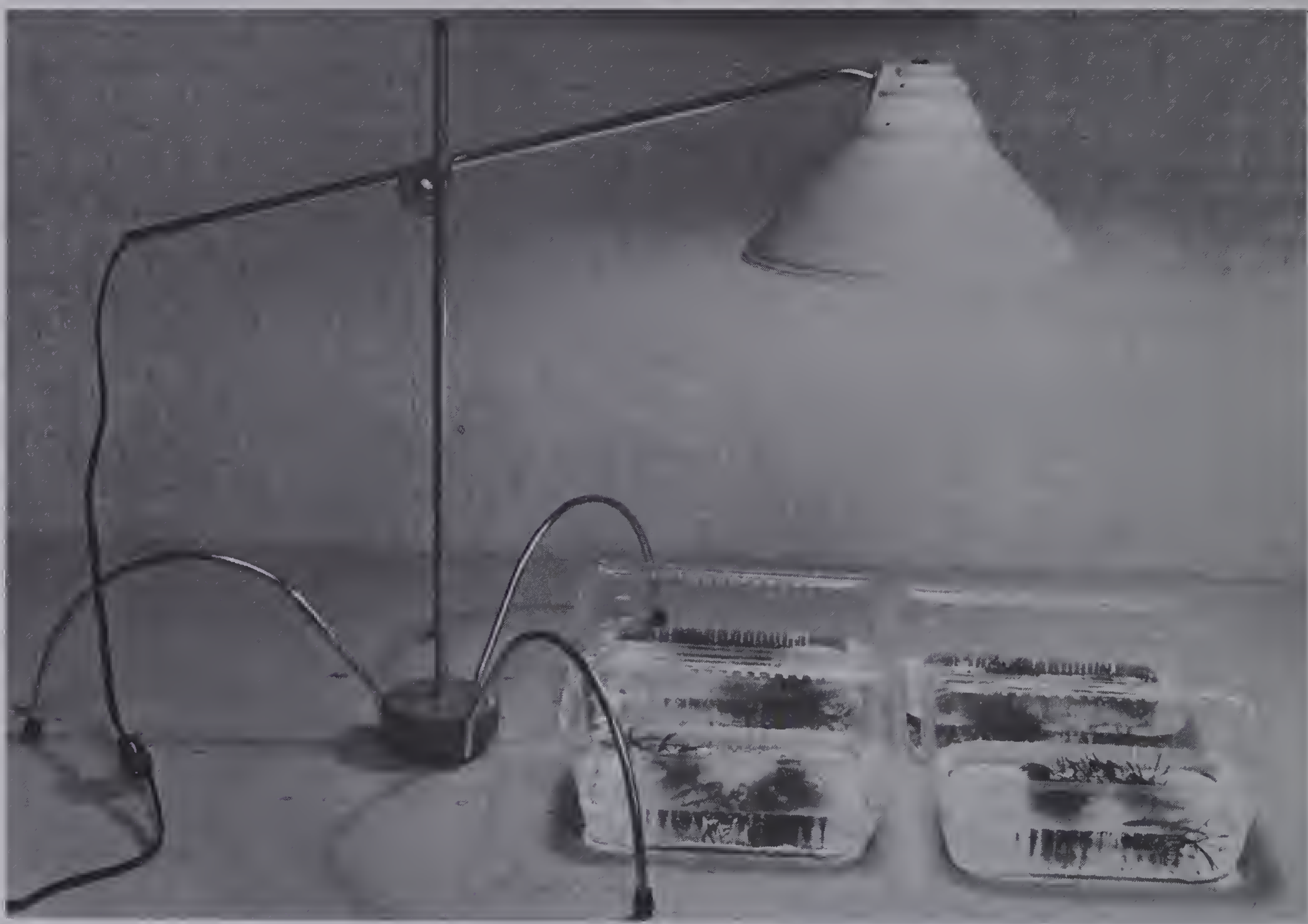


Figure 16-2. Adjust the light source to provide optimum amounts of heat and light.

Observing the populations. Give the children time to observe their aquariums over the next few days. Encourage them to report any changes they observe.

- Some students may notice clusters of yellowish transparent spheres on the leaves of aquatic plants or on the sides of the aquarium.
- Children who have had the *Organisms* unit may recognize these as snail eggs.
- If they do not, let them speculate about what they are and where they come from.
- Have them circle the eggs on the outside of the aquarium with a felt pen to mark their location and observe these with a magnifier.
- A plant on which eggs have been laid can be cut off and placed in a tumbler of aquarium water.
- The children can observe the development of the eggs daily.

17 Damselflies and Daphnias

SYNOPSIS

Children add damselfly nymphs and daphnia populations to their aquariums.

Children observe the interactions of the populations in the aquariums.

Suggested time: ***one session***

TEACHING MATERIALS

For each team of four children:

aquarium (prepared in Chapter 16)

Drawer 2

2 magnifiers

Drawer 3

1 medicine dropper

For the class:

damselfly nymphs†
daphnias†

Drawer 1

Aqaurium Populations chart
colored dots

Drawer 3

16 plastic tumblers
1 pipe cleaner

Drawer 6

baster

† in Shipment P-3

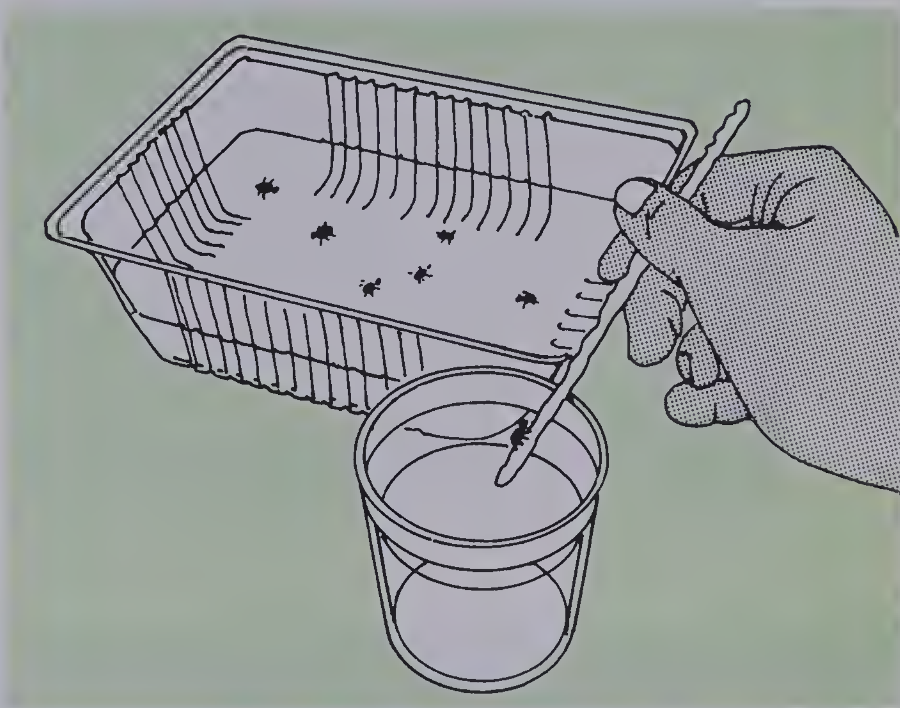
ADVANCE PREPARATION

Cut the gummed labels apart for easy distribution. Record each team's identifying number or letter on the Aquarium Populations chart.

Pour about ¼ cup of aged tap water into each of eight tumblers. Use a pipe cleaner to transfer two damselfly nymphs to each tumbler. To do this, slip one end of a pipe cleaner under the damselfly nymph and lift. The nymph will cling to the pipe cleaner.

Use the baster to transfer a little algae water and five to ten daphnias to each of eight additional tumblers.

Figure 17-1. Transferring damselfly nymphs *(above)* and daphnias *(below)*.



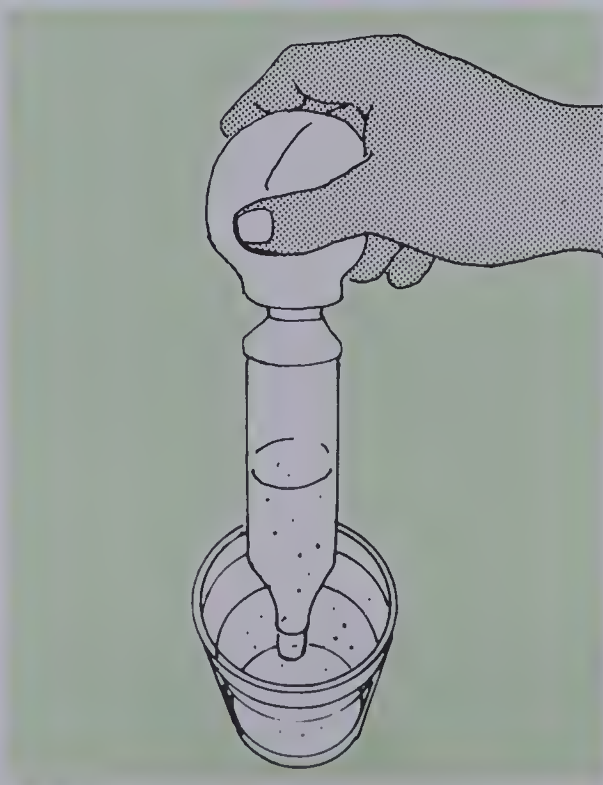


Figure 17-2. Two stages in the damselfly life cycle: larva *(above)* and adult *(below)*.

TEACHING SUGGESTIONS

Because the interactions of populations in the aquariums are the same as those in the terrariums, Chapters 17 and 18 together make up a discovery lesson in such concepts as *food chain* and *predator-prey*.

Damselfly nymphs. Tell the children that you have two aquatic populations for them to add to their aquariums. Explain that both are animals; one is the daphnia, with which they are already familiar, and the other is a new animal called a damselfly.

Tell the children that the damselflies they will be adding are in the larval stage of their life cycle. Children who have studied the *Life Cycles* unit may recall that a larva is an immature stage in the life cycle of an organism. Invite your pupils to name other larvae with which they are familiar. They might mention mealworms, tadpoles, or caterpillars—these are the larval stages of beetles, frogs, and moths or butterflies. (In some *Populations* classrooms, especially if the unit is taught in the spring, the nymphs will become adults and fly away.)

Give each team a tumbler containing damselfly nymphs. Suggest that the children observe the organisms with magnifiers. After a short observation period, tell the teams to pour the contents of their tumblers into their aquariums.

Using student manual page 15. Remind the groups to add the name and number of the damselfly population to their list. Afterward, have them keep their manuals out and record the numbers as mentioned below.

Daphnias. Give each team a tumbler containing daphnias and tell the students to use the medicine droppers to transfer five daphnias to each aquarium. Remind the teams to add the name and number of the daphnias to their list of organisms on page 15 of their student manuals.

Aquarium Populations chart. After the students have recorded the numbers of all animals added to their aquariums on page 15 of their student manuals, post the Aquarium Populations chart. Point out that there is a space on the chart for each team's record. Then give the students the colored dots from the kit. Tell them to use a different color for each kind of animal in the aquarium and to represent each organism with one dot. Ask one member of each team to stick the appropriate number of dots to the chart.

Planning ahead. We have found that the activities in Chapter 18 are more interesting for the children if they have not seen the daphnias being eaten by the damselfly nymphs in Chapter 17. Therefore, allow very little time for observation of the aquariums after the daphnias have been added until you actually begin Chapter 18.

Figure 17-3. Adding daphnias to an aquarium.

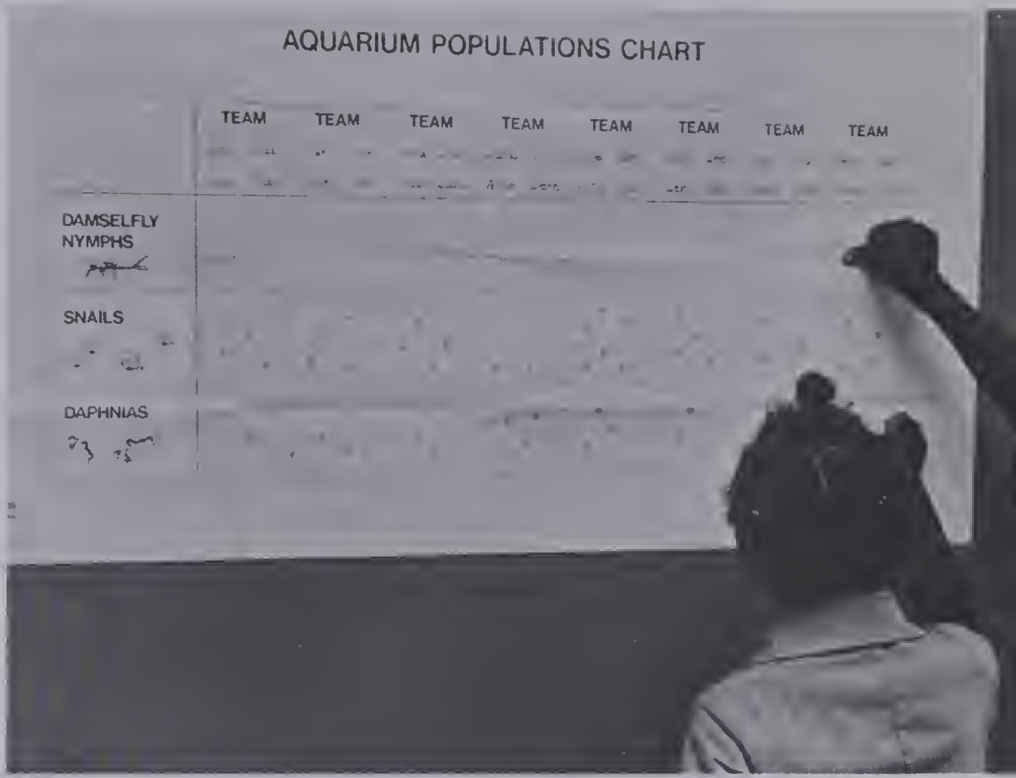
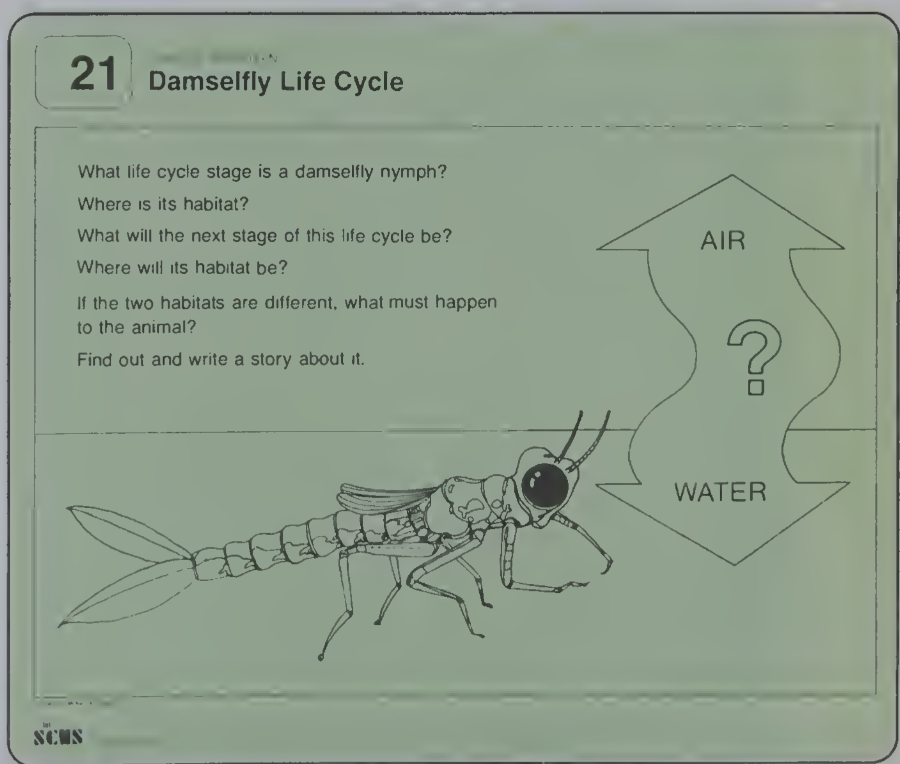


Figure 17-4. Recording the sizes of the aquarium populations.

EXTENDING YOUR EXPERIENCE CARDS

21. Damselfly Life Cycle. In changing from the larval (nymphal) stage to an adult, the damselfly must develop structures that allow it to survive in air rather than in water. The most obvious change is in the respiratory system—the gills are lost, and air-breathing structures appear. The child will have to use a library for this activity.



18 Aquatic Food Relationships

SYNOPSIS

Children observe the populations in their aquariums and record the number of animals.

Children suggest possible food relationships among the aquatic populations.

Children design and carry out experiments to check their hypotheses.

Suggested time: ***about four sessions over two and one-half weeks***

TEACHING MATERIALS

For the class:

The materials required will vary depending on the kinds of experiments the children design. The following list includes most of the items they will need:

aquariums
aged tap water
daphnia culture
scissors*
felt pen*

Drawer 1

colored dots
Aquarium Populations chart

Drawer 2

vials

Drawer 3

medicine dropper
plastic tumblers
pipe cleaners

* provided by the teacher

ADVANCE PREPARATION

Be certain that there is plenty (at least 8 liters) of aged tap water available for the children's experiments.

TEACHING SUGGESTIONS

This chapter continues the discovery begun in Chapter 17. The children extend their understanding of feeding relationships among populations to include aquarium populations.

Using student manual page 15. Have the students obtain their aquariums and count the number of each animal population. These numbers are to be recorded in their student manuals under *Number remaining.* If there are more animals of any kind than there were before, ask the student to add the approximate number of colored dots to the Aquarium Populations chart. If there are fewer, ask them to cross out the appropriate number of dots to designate the missing animals.

Discussion. When the teams have finished counting and recording, have them put away their aquariums and gather for a discussion. The children will see from that data on the chart that some of the populations in their aquariums have changed in number. Ask them what might have caused the increase or decrease. Most children will conclude that some organisms ate others, but they will probably disagree about which were the predators and which the prey. Allow sufficient time for the children to discuss their ideas.

Possible food relationships. Write the names of the three animal populations on the chalkboard as shown in Figure 18–1. Explain that you will diagram the possible food relationships using each team's data.

- Ask the children to look at the chart and tell what food relationships the first team's data indicate.
- If the record shows two damselfly nymphs and no daphnias, someone may suggest that the daphnias are eaten by the damselfly nymphs.
- You should then draw an arrow from daphnias to damselfly nymphs on the chalkboard. If the team's record shows three snails, the children may suggest that these also eat daphnias; an additional arrow from daphnias to snails should be added. Another team's record might show no damselfly nymphs, twenty daphnias, and only one snail. This would result in arrows from snail and damselfly nymphs to daphnias, contradicting the other team's data.
- Continue adding arrows to indicate each team's record. (Because you will need this diagram later, copy it on a piece of paper.) The completed diagram may resemble the one in Figure 18–2.

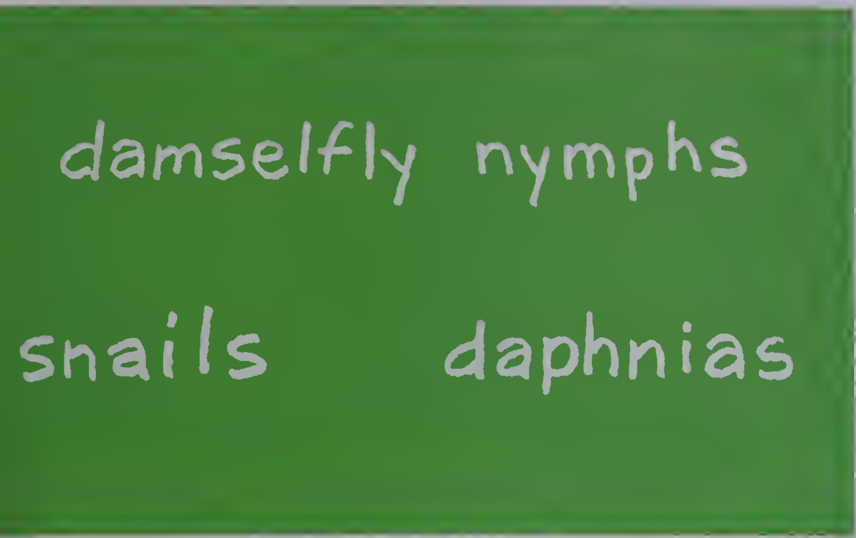


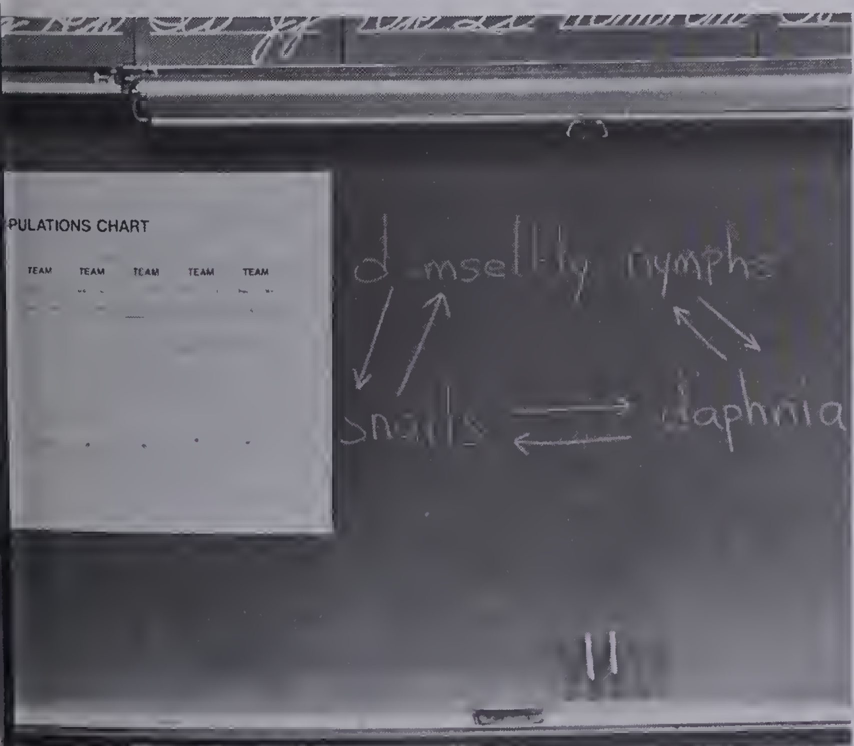
Figure 18-1. The aquarium populations.

- Have the children help you make a list of each feeding interaction shown on the diagram. Tell them you will use the abbreviation DFN for damselfly nymphs.
- The list will include some or all of the following interactions:

daphnias ⟶ DFN
DFN ⟶ daphnias
daphnias ⟶ snails
snails ⟶ daphnias
DFN ⟶ snails
snails ⟶ DFN

- Ask the children whether they think all these food relationships actually exist. Then suggest they experiment to find out. Tell them they may use any of the available materials and that team members should select one possible feeding relationship to investigate.

Figure 18-2. Possible food relationships in the aquarium.



- Each relationship should be tested by at least one team, but you might prefer to have each team test more than one possibility in order to obtain more data. The number of experiments your class is able to do will depend, of course, on the number of animals (especially damselfly nymphs) remaining in the aquariums.
- One student on each team should write the team's number next to their selection on the classroom list.
- The list actually contains pairs of contradictory statements. The children may not realize that only three experiments are necessary to test the six possible feeding relationships. You need not point out the contradiction as it will be discovered later.

Experimental design. The amount of freedom you allow the teams in designing their experiments depends on your judgment of their ability to work independently. Children who are able to design and carry out experiments to answer a question should have the opportunity to apply their skills. Other students may find too much freedom defeating, which can result in aimless wandering. Consider the children's performance in previous activities in order to decide how much freedom to allow.

You may proceed in either of the following ways:

1. Arrive at the experimental design through class discussion, outlining the procedure on the chalkboard as children offer suggestions; or
2. Work with some teams individually, helping members design their experiments while other teams design their experiments independently. (In this case you may wish to require a drawing or explanation of the experiment before the children proceed.)

Whichever approach you elect, it may be necessary for you to ask questions that will help the children think through the various phases of their team's experiment:

- Have they agreed on the equipment they will use?
- If an organism disappears, how can the class be certain that it was eaten? Could the organism simply have died or left the container? Could the children set up their experiment in such a way that they would be certain of what happened?

Discussion of the last question should help children realize the need for controlled experiments. If they do not suggest a control or are uncertain how to proceed, you may want to review the idea that in a controlled experiment there are two setups which are alike in all ways but one. If, for example, the children think that damselfly nymphs eat daphnias, they could

put both kinds of organisms (only) in one container. If daphnias disappear from the first container but not from the second, the children should infer that the damselfly nymph is responsible for the daphnias' disappearance.

Experimental setup. Let teams obtain the necessary materials and set up their containers. Remind them to label the containers with the team number and the name and number of each kind of animal. After allowing time for observations, the teams place their containers near the aquariums.

Results. During the next day or two, provide additional time for the teams to examine their experiments and determine the results.

Using student manual page 16. Have each child make a drawing of his or her experiment. Under the drawing they should record their results. Ask the pupils to return the organisms to the aquariums and then gather for a discussion. Redraw the diagram showing the possible food relationships. Then ask a child from each team to report the results of each team's experiment. As the results are reported, alter the diagram to reflect the feeding interaction discovered by the children. The new diagram should show just one arrow between any two organisms.

16 Chapter 18

My experiment:

Results:

____

____

____

____

____

____

____

____

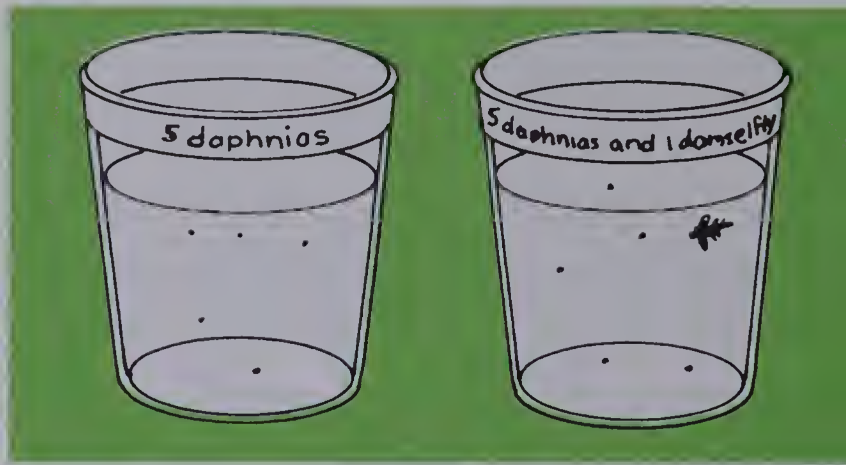


Figure 18-3. A controlled experimental setup.

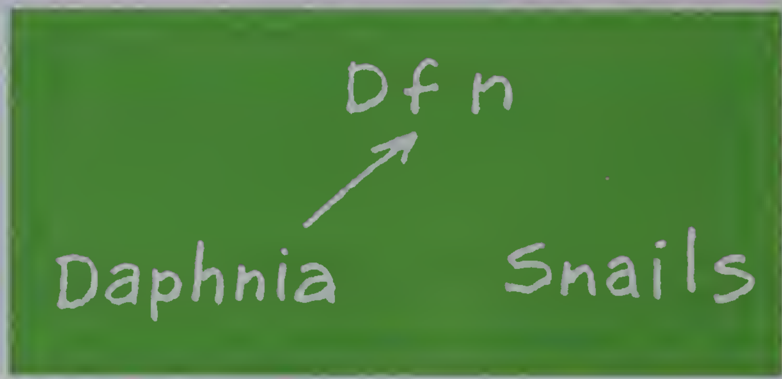


Figure 18-4. Interpreting the experimental data.

Adding plants to the diagram. Ask the children what other populations they added to the aquariums.

- As they respond, add the plant names algae, *Wolffia,* and hornwort randomly about the diagram.
- Then ask if anyone observed animals eating plants.
- Draw arrows from the plant names to the appropriate animals for each food relationship that the children suggest; then ask for evidence to support each statement.
- Children may refer to the color of the daphnia's intestine, or they may produce a chewed sprig of hornwort as evidence that a snail has been eating the leaves.
- If the children are slow to respond, ask which animals might eat which plants and add question marks to these arrows.
- Now write the possible feeding relationships on the chalkboard.
- Your list may resemble the following:

  algae → daphnias
  hornwort → snails
  algae → snails
  Wolffia → snails
  Wolffia → DFN

- Circle the feeding relationships about which the children disagree or for which there is no evidence.

• Then ask how these might be tested.

Experimenting. As in previous experiments, have each team decide which food relationship it will investigate and place its team number next to these on the chalkboard.

You may again find it necessary to review the idea of controlling an experiment. A test to determine whether snails eat *Wolffia* could consist of one tumbler or uncapped vial containing a snail and *Wolffia* plants. A control would contain the same number of *Wolffia* plants but no snail.

Permit the children to obtain their materials and set up their experiments. Remind them to label the containers with their team number and the number of each kind of organism, and to place the containers near the aquariums.

Diagraming the results. In about two days, let the teams observe their experiments and determine the results. Redraw the food relationship diagram and have teams report their final results. Proceed as before, altering the diagram to reflect the results of the children's experiments. Then explain that this diagram illustrates all the food relationships in the teams' aquariums.

Cleanup. Activities dealing with aquariums are now completed. However, you may wish to maintain them long enough to allow your students to observe the damselflies reach adulthood. (This is more probable in the spring than in the winter.) In this case, keep the daphnias as a source of food. If algae fail to grow, add a small pinch of active dry yeast to the daphnia containers every few days. Damselflies also eat small aquatic animals which can be netted from a quiet pond or stream. Large nets can be made from sticks and cheesecloth.

When the aquariums are dismantled, give the organisms to other teachers or dispose of them in a waste container. Rinse the containers and return them to the kit.

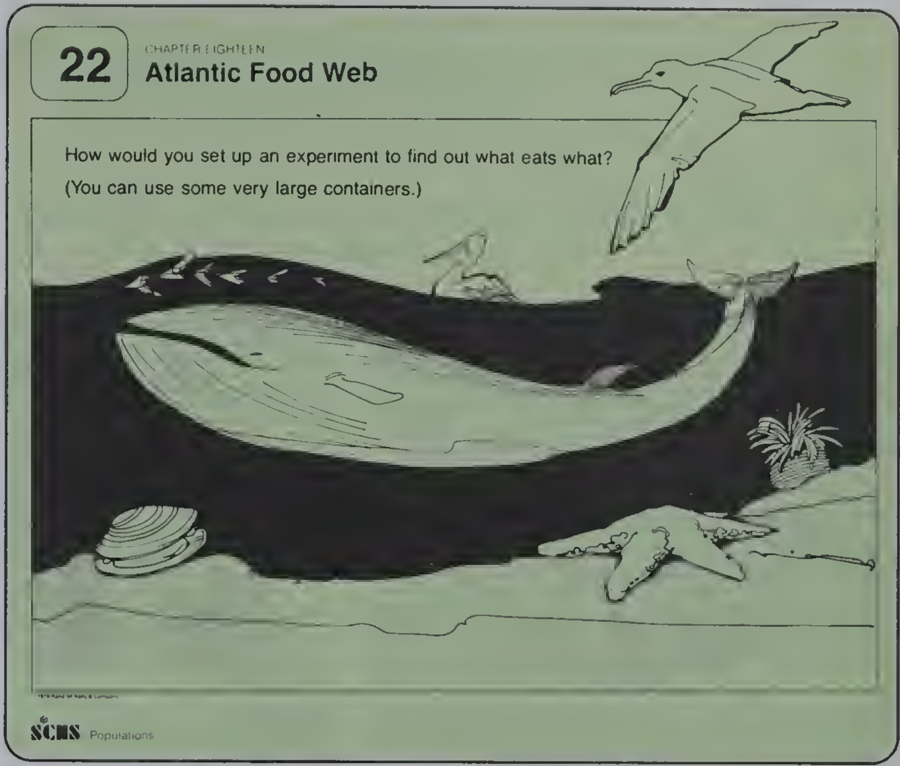
EXTENDING YOUR EXPERIENCE CARDS

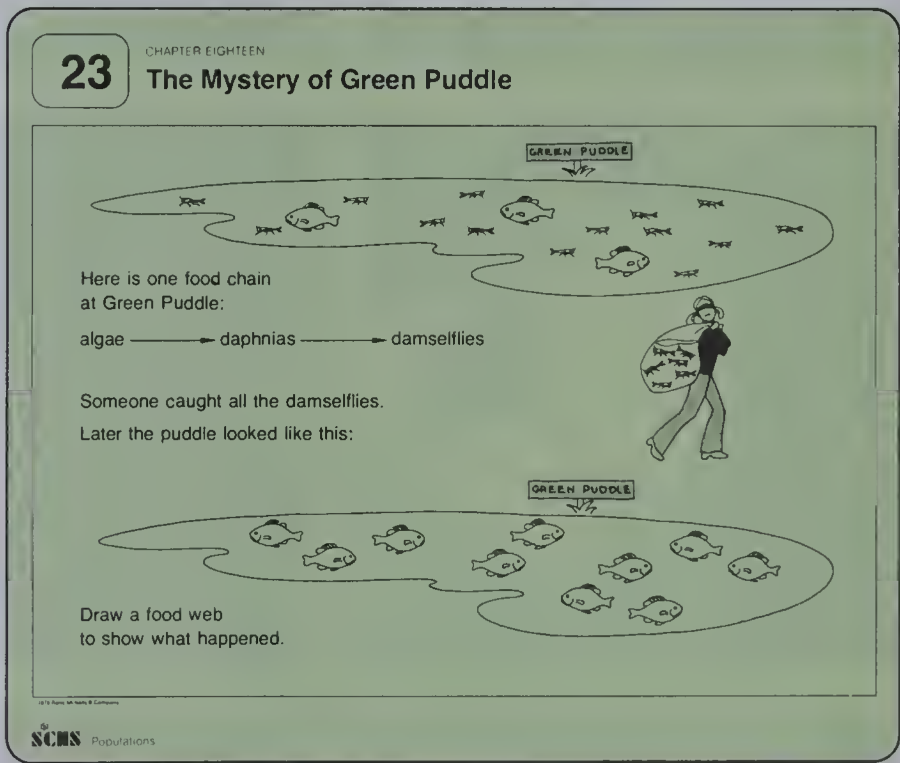
22. Atlantic Food Web. If the child understands the principle of this chapter's experimental design, he or she will be able to suggest similar setups for the large organisms pictured.

23. The Mystery of Green Puddle. The food web probably looked like this:

algae ⟶ daphnias ⟶ damselflies
                              ↘ fish

When the damselflies were removed, the fish had no competitors for the daphnias, and so the fish population increased.





Extending Your Experience cards 1–23 are now available for the children's use. For materials needed, refer to the equipment list accompanying the set of cards.

CONCEPT / PROCESS EVALUATION

If you choose to evaluate the children's abilities to plan and carry out experiments, turn to the evaluation section on page 80 at the back of the guide.

Appendices

RAND McNALLY
SCIS

Evaluating Your Students

SCIIS bears upon many aspects of each child's growth and learning, and evaluation may therefore take a variety of forms. We believe the most significant evaluation should occur informally, while the regular classroom activities are going on and you can observe each child's attitudes, skills, and performance, rather than in formal "test" situations. Test scores alone are not appropriate to describe attitudes, and they often are inadequate measures of children's skills or understanding of science concepts. For these reasons we have provided three kinds of evaluation activities:

A. CONCEPT/PROCESS EVALUATION
- **Activity 1. Causes of Population Change**
- **Activity 2. The Population Concept**
- **Activity 3. Feeding Relationships**
- **Activity 4. Discussing Experiments**

B. ATTITUDES IN SCIENCE
- **Curiosity**
- **Inventiveness**
- **Critical Thinking**
- **Persistence**

C. PERCEPTION OF THE CLASSROOM ENVIRONMENT
- **Our Science Class**

An important feature of the evaluation materials is that they can help you identify problem areas and plan more effective teaching of subsequent parts of the unit. In concept/process evaluation, the "Follow-up" section at the end of each activity provides specific suggestions for remedying weaknesses in student understanding. The materials for assessing children's attitudes and their perception of the classroom environment contain suggestions that can help you improve your teaching effectiveness as well as the attitudes and performance of students. We hope you and your students find these activities both enjoyable and beneficial.

Concept / Process Evaluation

The activities in this section are designed to help you evaluate children's ability to identify and describe the major science concepts and processes of the unit. As explained in the unit "Overview" on page 1, these major concepts and processes are:

population	**food web**	**animal-eater**
plant-eater	**biotic potential**	**plant-animal-eater**
		predator-prey

In addition, certain secondary concepts and processes are introduced to help the children deal with their observations. These are: dispersal, barrier.

Objectives indicating the concepts and processes emphasized are listed at the beginning of each Part in the Teacher's Guide. Children's understanding and mastery of most concepts and processes can be evaluated informally as the class works through regular activities. It is worthwhile to evaluate children more than once during the unit, because individuals will achieve desired levels of competence at different times.

All of the concept/process evaluation activities can be carried out with individuals or small groups. Thus, you can use an activity to evaluate just the children for whom you are lacking notes or observations. Some activities also lend themselves to use with the whole class; this is indicated where appropriate.

The activities in this section provide you with ways to evaluate children's understanding of major concepts and processes presented in this unit. Some of the activities will also provide information about understanding of concepts and processes that are of secondary importance in this unit or that were introduced in earlier units.

Keeping records. One side of the Class Profile sheet (Evaluation Materials envelope, drawer 1) provides space to record results of each child's work in each activity. In evaluating children's progress we have found it most useful to distinguish three levels of understanding. These levels, and symbols convenient for recording them, are:

○ **Needs special assistance**
✓ **Check again**
● **Satisfactory**

The symbols have the advantage of being changed easily after a child gives evidence of progress. In addition to the symbol, you may add brief comments in the "Notes" column.

EVALUATION
ACTIVITY

1 Causes of Population Change

SYNOPSIS

This activity assesses the children's understanding of the effects of birth and death on population size.

Administer: *to entire class after Part One*

Suggested time: *5 minutes*

EVALUATION MATERIALS

For each child:

1 copy of Population Increase answer page*
1 pencil*

For the class:

Drawer 1

Population Increase spirit master

* provided by the teacher

EVALUATION SUGGESTIONS

Distribute the answer pages. Tell the class that the pictures show two different groups of rabbits, and that the rabbits lying down in the right-hand picture are dead.

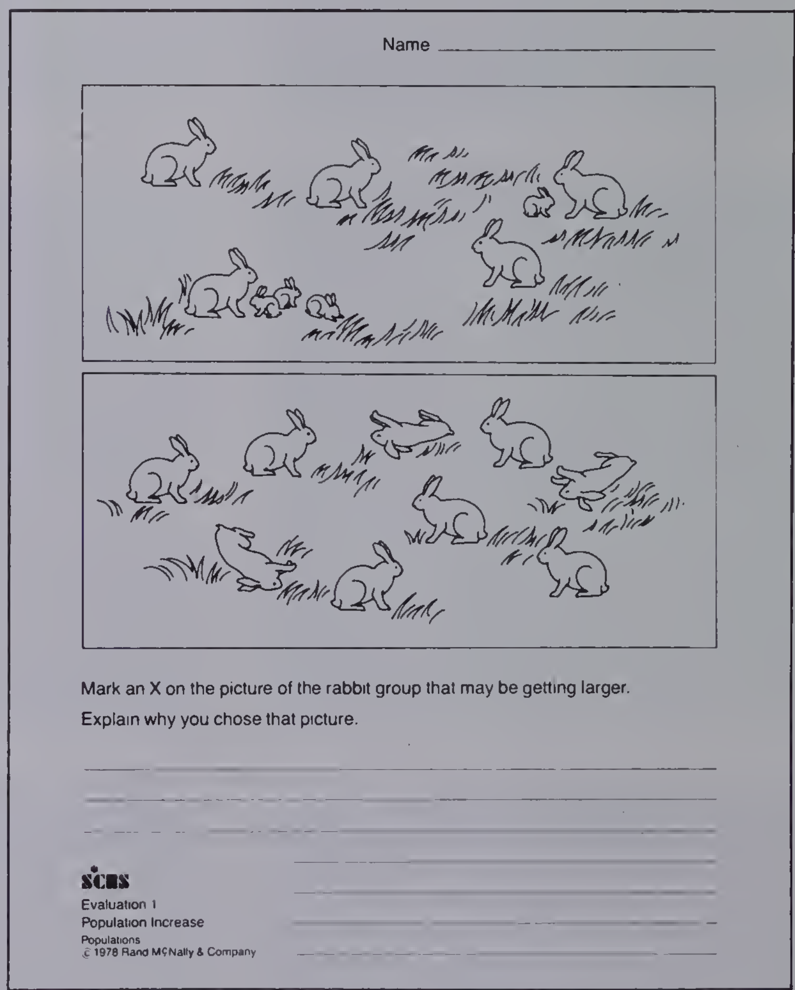
Ask the children to mark an "X" on the picture of the group that may be getting larger. Each child should then explain his or her answer on the lines below the pictures. Collect the pages when the children finish.

Criteria. Examine the children's explanations of why they chose one picture or the other.

- Children who chose the picture on the left probably recognize that, although the number of rabbits in each picture is the same, the presence of young and the absence of dead indicate that the group is getting larger.
- Children who selected the picture on the right may not understand that birth is the cause of population increase and that death is the cause of population decrease.
- If any children's written explanations do not reflect these ideas, you may wish to question them further.

Follow-up. Children who failed to relate birth to an increase in the size of a population and death with a decrease in size apparently did not understand or properly interpret their experiences with daphnia and aphid populations. Review with these children the results of the population counts and question them individually about the causes of population increase and decrease. If necessary ask them how new organisms come into the world and how organisms leave it.

Figure E-1. The Population Increase ditto master.



EVALUATION
ACTIVITY

2 The Population Concept

SYNOPSIS

Using this activity, you determine the children's understanding of the population concept and the effects of birth and death upon a population.

Administer: ***to entire class after Part One***

Suggested time: ***10 minutes***

EVALUATION MATERIALS

For each child:

1 copy of Populations answer page*
1 copy of Population Size answer page*
1 copy of Population Growth answer page*
1 pencil*

For the class:

Drawer 1

Populations spirit master
Population Size spirit master
Population Growth spirit master

* provided by the teacher

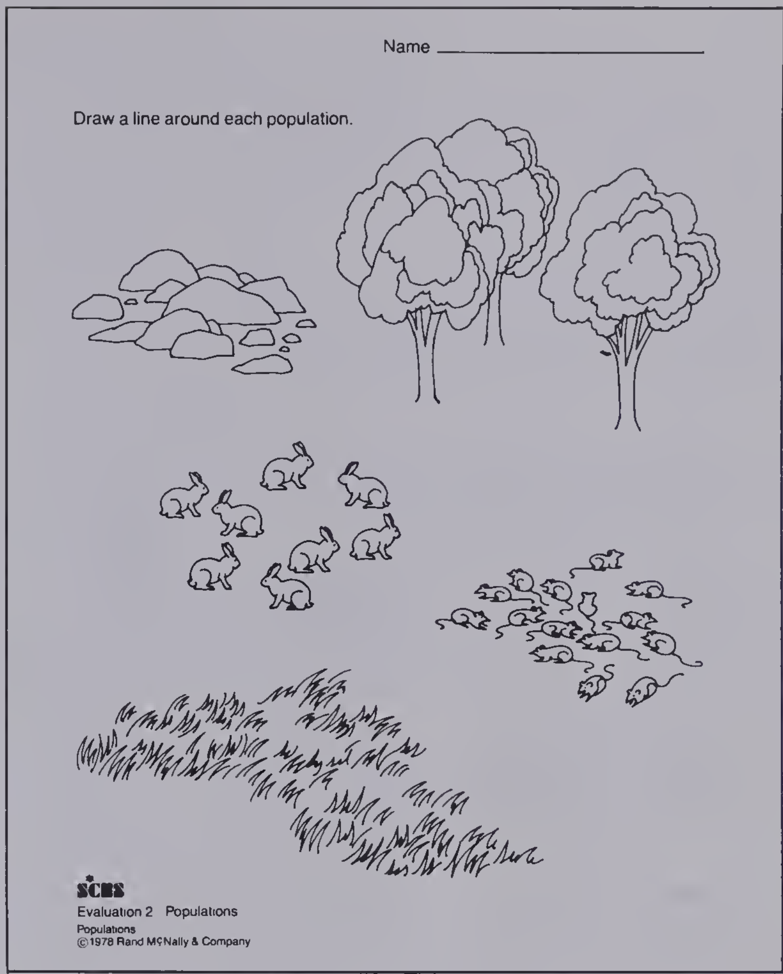
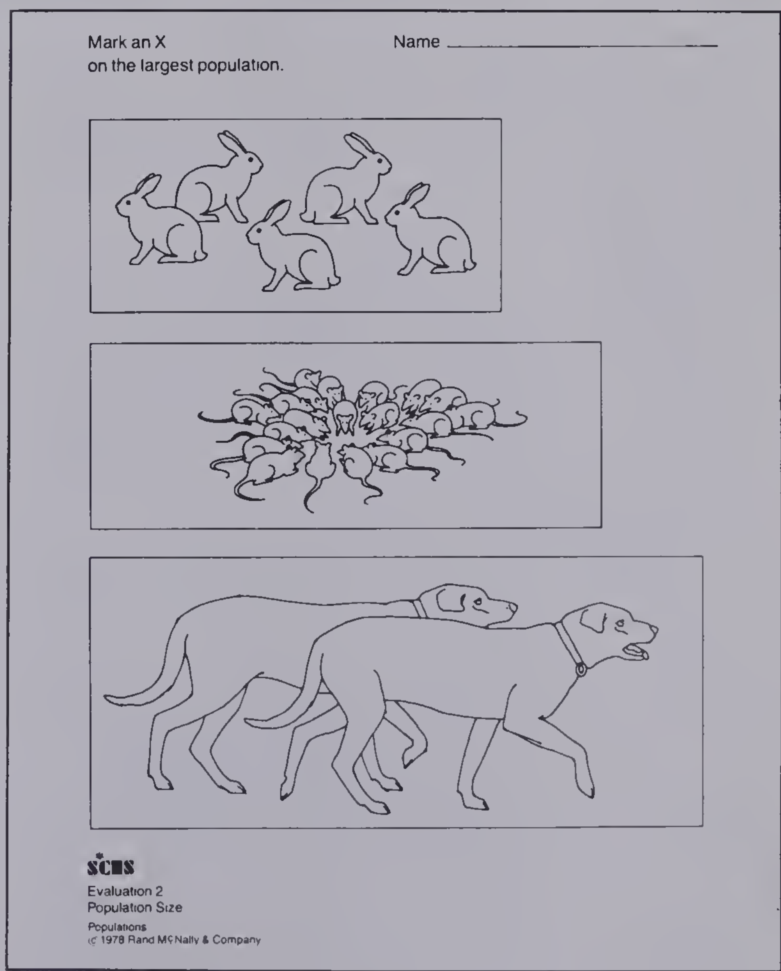


Figure E-2. The Populations ditto master.

Figure E-3. The Population Size ditto master.



EVALUATION SUGGESTIONS

Distribute a copy of each answer page to each child. Read the instructions for the Populations answer page with the class. Walk among the children while they are working and give assistance if necessary.

When the students are finished, read the instructions for the Population Size answer page and give them a moment to decide which population is the largest.

Now call attention to the four pictures on the Population Growth page and read the instructions with the class. Allow the children a few minutes to choose their answers and explain them.

Collect the answer pages.

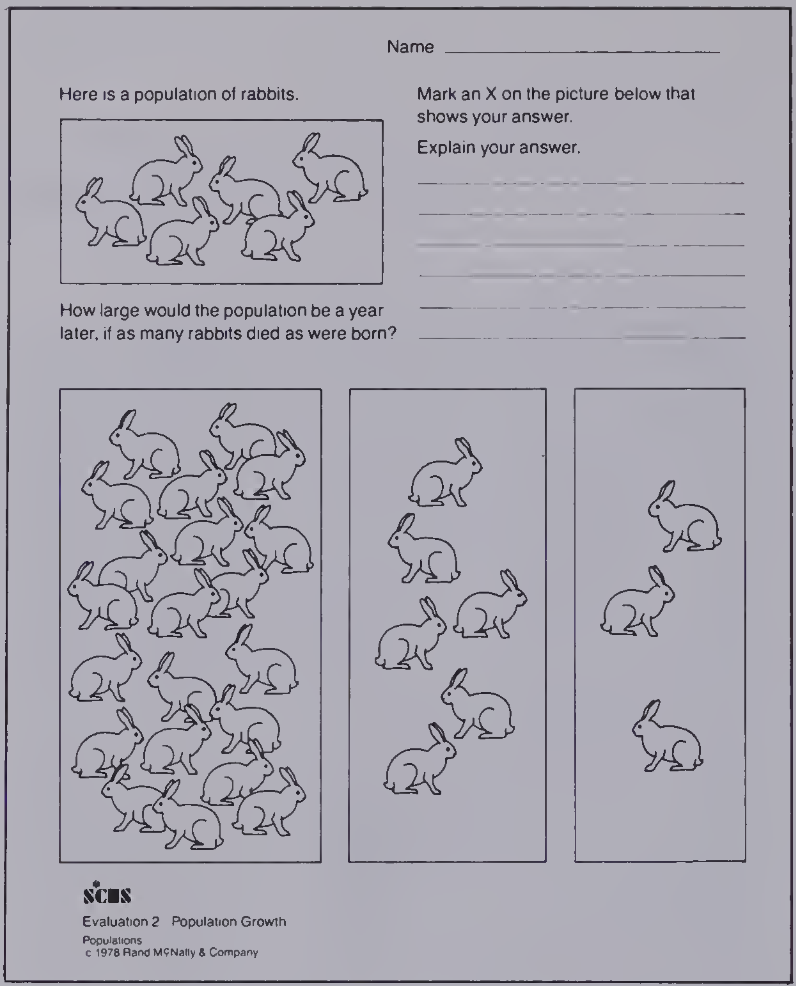


Figure E-4. The Population Growth ditto master.

Criteria. Examine the children's answer pages and compare them with the criteria below.

Populations. Children exhibit a satisfactory understanding of the population concept if they have enclosed all of the rabbits in one encircling line, all the trees in another, all the mice in another, and all the grass in another.

- Children who enclosed rocks may not know that populations are composed of living things only, or they may think rocks are alive.
- Children who drew lines around individual organisms rather than all the members of a population may not know that populations are *groups* of the same kind of organisms.
- Those pupils who enclosed two or more populations within one encircling line may not understand that a single population consists of only one kind of organism.
- You may wish to speak individually with children who made errors to determine the nature of their misunderstanding.

Population Size. Children who marked the box containing the mice probably understand that population size is dependent upon the number of individuals.

- Children who marked the other boxes may mistakenly think that the size of the organisms in a population, or the space they occupy, determines the size of the population.

Population Growth. Children who marked the middle picture on this page indicate a satisfactory understanding of the effects of equal birth and death rates on a population.

- Their written explanations should reflect the idea that a stable population results when births equal deaths.
- You may wish to talk with pupils whose answers surprise you in order to determine their reasons.

Follow-up. Work individually with the children who do not understand the meaning of the term population. Review the activities leading up to the introduction of the term and then reinvent the term. After this, question the children to make sure they have a proper understanding.

If any children assume that the size of a population is determined by the size of the individuals, review with them the definition of the term population and then review with them their counts of daphnia and aphid populations. Ask them whether the individuals changed in size as the populations got bigger.

For the children who do not understand the relation of birth and death to increase or decrease in the size of a population, review the daphnia and aphid counts and ask them where the new individuals came from that caused the increase in size of the population. Also ask them what happened to the individuals when the population size decreased. In the case of the aphids both death and dispersal would be correct responses.

EVALUATION ACTIVITY

3 Feeding Relationships

SYNOPSIS

This activity assesses the children's ability to identify feeding relationships among specific organisms and classes of organisms.

Administer: ***to entire class after Part Three***

Suggested time: ***10 minutes***

EVALUATION MATERIALS

For each child:

1 copy of Food Chain answer page*
1 copy of Food Web answer page*
1 copy of Feeding Relationships answer page*
1 pencil or crayon*

For the class:

Drawer 1

Food Chain spirit master
Food Web spirit master
Feeding Relationships spirit master

* provided by the teacher

EVALUATION SUGGESTIONS

Distribute the answer pages and read the instructions for the Food Chain answer page. Be certain the children recognize the organisms illustrated before giving them time to draw their arrows.

Read the instructions on the Food Web page and give the children a moment to record their answers. The children should be able to respond to the instructions quickly.

Now read the instructions on the Feeding Relationships page, but do not explain the terms or give examples that the children know. If you do, you will not discover whether the children know the terms or can generalize from the specific experiences they have had.

Collect the answer pages.

Criteria. Examine the children's answer pages and compare them with the following criteria.

Food Chain. Children who drew arrows pointing from the grass to the cricket to the chameleon indicate a satisfactory understanding of the food chain concept.

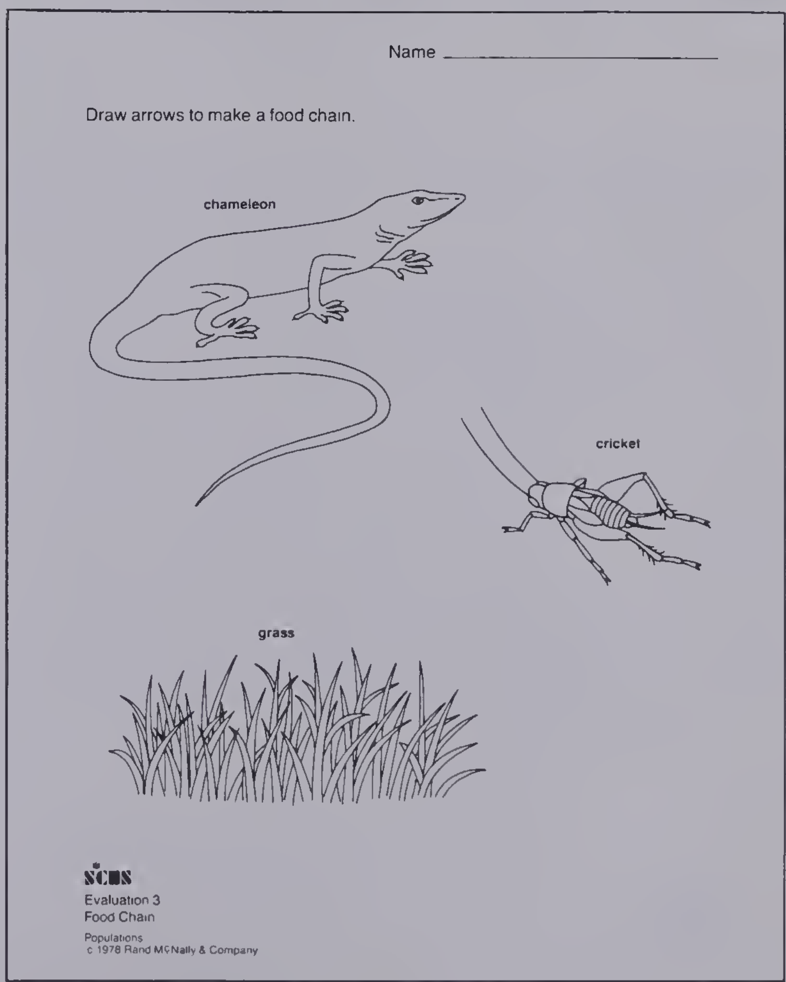
- You may want to speak individually with children who reversed the direction of the arrows or did not connect the appropriate organisms to determine the nature of their misunderstanding about food chains.

Food Web. Children who identified the top diagram as a food web show a satisfactory understanding of this concept.

Feeding Relationships. Children who drew arrows from plants to plant-eaters to animal-eaters indicate an understanding of the relationship between these general terms.

- Question children who positioned the arrows properly but reversed their direction; they may understand the relationship but do not remember what the arrows represent.
- Children who connected plants and animal-eaters with an arrow probably do not understand the generalized feeding relationships among organisms. These children need further experiences.

Figure E-5. The Food Chain ditto master.



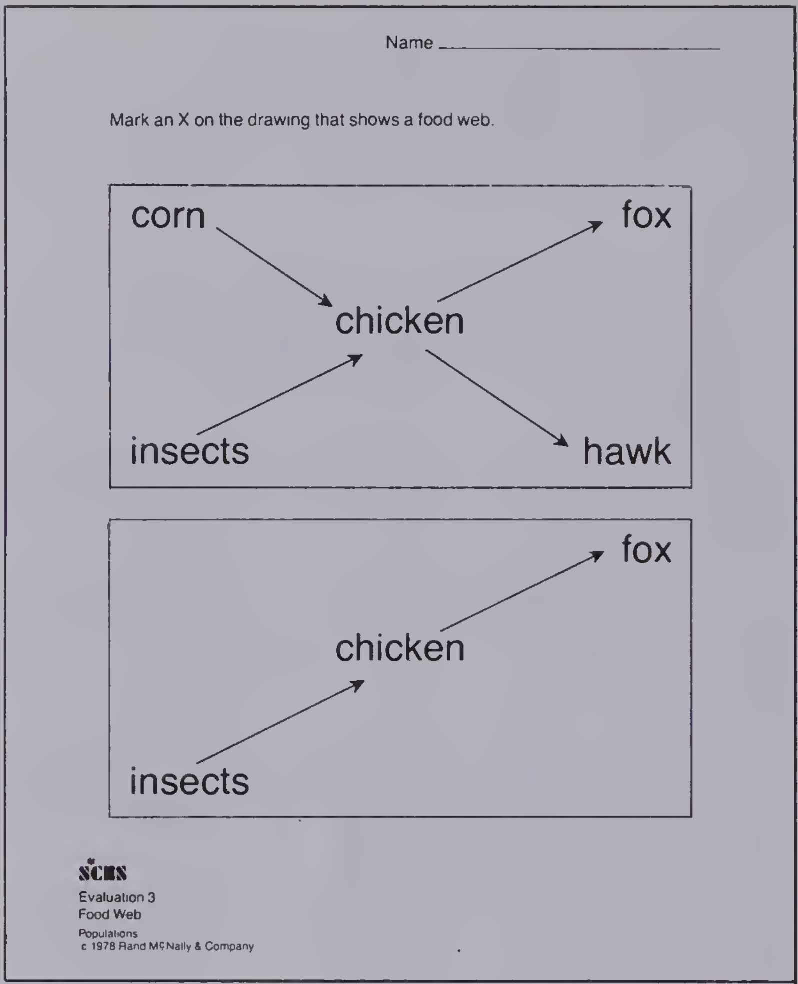
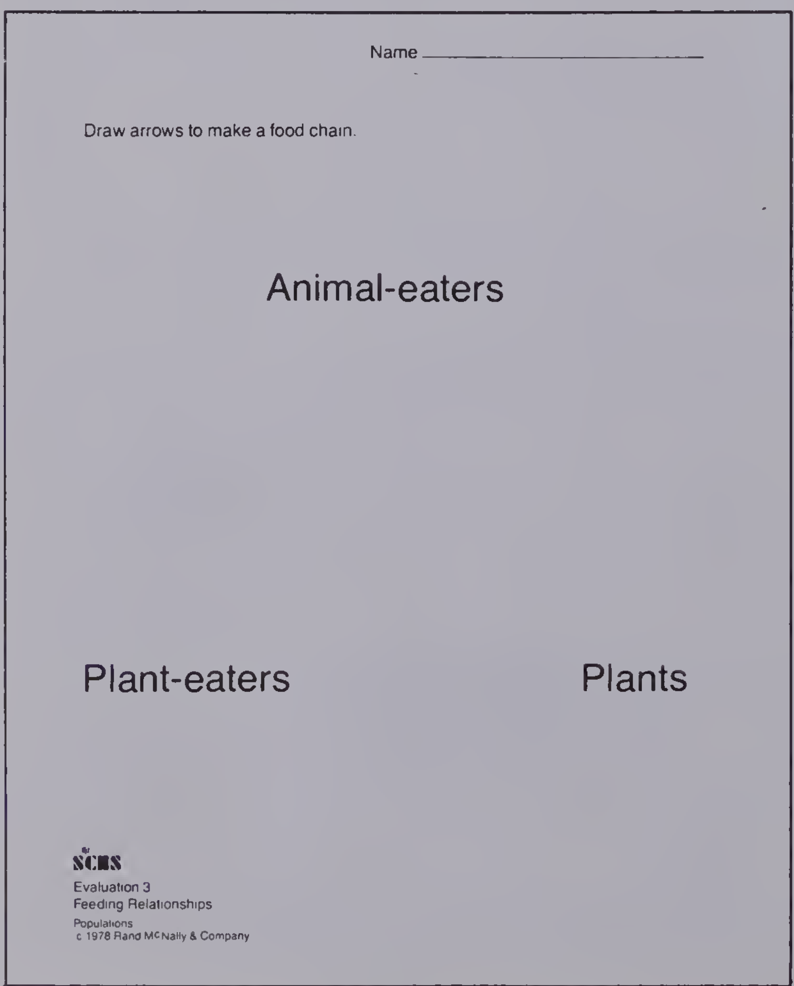


Figure E-6. The Food Web ditto master.

Figure E-7. The Feeding Relationships ditto master.



Follow-up. Understanding of food chains and food webs involves knowledge of "what eats what" plus an understanding of the relations of words and arrows that make up the diagrams of food chains and webs. First determine where the individual student's difficulty is and then review the particular activity in the chapter that relates to the difficulty.

EVALUATION
ACTIVITY

4 Discussing Experiments

SYNOPSIS

This activity assesses the children's ability to (1) propose hypotheses, (2) suggest experiments for testing hypotheses, and (3) draw conclusions from experimental data.

Administer: ***to groups of 4 or 5 children after Part Four***

Suggested time: ***10–15 minutes***

EVALUATION MATERIALS

For the group:

Drawer 1

Experiment picture

EVALUATION SUGGESTIONS

Gather four or five students at a table for an informal discussion. Show them picture *A*. (Do not let them see picture *B*, on the back of the card.) Allow the children time to look at the picture. Then ask them what they see in the container. If they do not mention the soil, beetle, rock, plant, or water droplets on the top and sides of the container, call their attention to them. Be certain they notice that the container is covered.

Suggesting hypotheses. Ask the group where the water droplets on the top and sides of the container could have come from. By turning your attention to different children, you will give each an opportunity to answer. Most children will suggest the plant, beetle, and the soil.

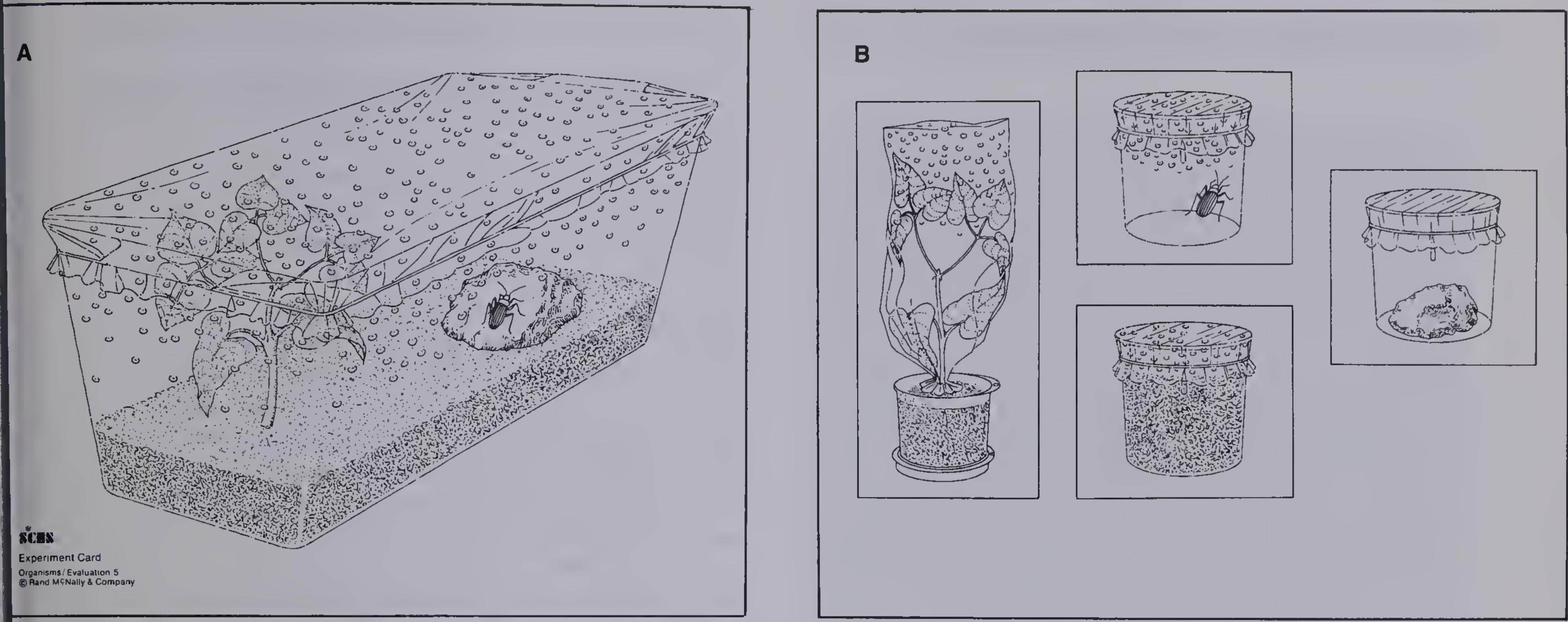


Figure E-8. The Experiment picture card.

Designing experiments. To determine how well the children can work together to design an experiment, ask them how they could find out where the water came from (or from which of the objects or organisms the water came). Allow the children to talk freely and to modify each other's designs. Children of this age may design controlled experiments, but in most cases they only suggest repeating the original events. However, some children will think of separating all the possible sources of moisture, just as they isolated the variables to determine why the daphnia populations decreased in Chapter 7.

Interpreting experimental results. Turn over the card and tell the group that picture *B* shows the results of an experiment to find where the water came from. Tell them each object was covered and left overnight. Give the children time to observe the pictures and to notice which of the setups contain water droplets. Then ask, "Now do you know where the water came from?" Most children will recognize that water was produced by the organisms and the soil, but not by the rock.

Criteria. A child who can suggest hypotheses and interpret the results has given a satisfactory performance. A child who can also suggest a reasonable experiment evidences superior ability. Those children who were unable to contribute at all or whose contributions were irrelevant show they have not had sufficient experience with the processes involved in experimenting.

Abilities to propose hypotheses, design experiments, and interpret results are among the major objectives of the entire six-year SCIIS program. You should therefore not expect children to exhibit a great deal of sophistication during this activity.

Follow-up. There is no single activity that you can involve the children in that would completely clarify their understanding of the process of controlled experimentation. However, you can do something to help them develop a partial understanding of the process. First, show picture *A* again and ask your students what the question was that they were asked to answer. A clear understanding of the problem is essential for any experiment. Second, show picture *B* and ask the children why each object pictured in picture *A* was confined to a separate closed container. Third, ask the children to tell you which containers in picture *B* showed water and which picture did not. Then ask them how their information helps them to answer the question of the source of the water droplets in picture *A*.

Attitudes in Science

These comments are designed to help you assess four major attitude areas that can indicate developing scientific literacy in children.

When using this phase of evaluation, keep in mind the question "In what ways is the child behaving like a scientifically literate individual?" During your day-to-day science teaching, look for evidence of positive attitudes in the following areas:

Curiosity. Children who pay particular attention to an object or event and spontaneously wish to learn more about it are being curious. They may give evidence of curiosity by—

- using several senses to observe organisms and other objects
- asking questions about objects and events
- eagerly examining organisms, equipment, or other materials at the time they are first distributed
- showing interest in the outcomes of experiments

Inventiveness. Children who generate new ideas are being inventive. These children exhibit original thinking in the interpretation phase of an activity. They may give evidence of inventiveness through actions or verbal statements by—

- using equipment in unusual and constructive ways
- suggesting new experiments
- describing novel conclusions from their observations

Critical thinking. Children who base suggestions and conclusions on evidence are thinking critically. They may exhibit critical thinking largely through verbal statements by—

- using evidence to justify their conclusions
- pointing out contradictions in statements by others
- changing their ideas in response to evidence

Persistence. Children who maintain an active interest in a problem or event for an extended period of time are being persistent. They are not easily distracted from the subject at hand. They may give evidence of persistence by—

- continuing to investigate materials after the novelty has worn off
- completing an activity even though their classmates have finished earlier
- redoing an experiment while making some manipulative or procedural changes to improve the results

Of course, the behaviors related to these areas are not restricted to science; they may be observed in other curriculum areas when suitable opportunities exist.

Observing a whole class busily engaged in diverse activities makes attitude-evaluation of individuals virtually impossible for one teacher. We recommend that you focus your attention on attitudes demonstrated by four or five children during each session. You may do this by following an alphabetical class list or by concentrating on one or two teams per session. If you learn something about four or five children during any one session, then you will be able to make a note about each child four or five times in the teaching of one SCIIS unit. Active, vocal children will gain your attention more frequently; quiet children may escape your notice for some time. Adopting a plan for observing class members ensures that you will not overlook any individuals.

In addition to observing the children, an effective way to measure attitudes is to ask divergent questions about the work they are doing. By listening carefully to their responses, you will obtain significant feedback regarding their attitudes.

Keeping records. Space is provided on the Class Profile sheet (Evaluation Materials envelope, drawer 1) for recording observations about each student's attitudes four times during the unit. In the "Notes" column, you may include a short statement indicating what you observed each time the child was selected. Many teachers make their notes while the children are cleaning up at the end of the activity.

The use of this informal but organized assessment system will provide you with a great deal of information about the children's development and will assist you in planning for effective instruction in science.

Perception of the Classroom Environment

This activity indicates how the children assess the nature of the classroom during science—or how they would like it to be. The activity answers the following questions:

- Do the children see science class time being used in the way you intend it to be used?
- Do they feel that they are active participants in science class?
- Which kinds of science activity—experimenting, writing or drawing, listening to the teacher, discussing, or reading—do they generally prefer?

Young children are sensitive to suggestions from adults. To avoid unduly influencing pupils' perceptions of the classroom, you must be completely noncommittal about what you think is most important or most interesting.

In our experience, most children prefer experimenting, but some do prefer to read or listen to the teacher. Certainly all five kinds of activity are important in a balanced science program, and they should be combined in a way that benefits children most. In field tests of these materials, teachers reported that they could anticipate many children's responses, but that there were usually a few whose perceptions or preferences surprised them and helped them to adjust their teaching accordingly.

The following activity has been written in a style similar to that of the regular SCIIS activities in the hope that the children will see it as a natural part of the learning sequence rather than as a formal examination. The activity may be used at the end of each Part in the unit.

Our Science Class

SYNOPSIS

Children use a chart to indicate (1) how they think science class time was used or (2) which kind of science activity they prefer.

Administer: ***to entire class at conclusion of each Part***

EVALUATION MATERIALS

For each child:

small piece of paper*

For the class:

Drawer 1

Our Science Class chart

*provided by the teacher

EVALUATION SUGGESTIONS

Post the chart in a prominent place and tell your pupils that the pictures show what might go on during a science session. To make sure they can interpret the pictures correctly, invite them to find the pictures that show children (1) experimenting, (2) writing or drawing, (3) listening to the teacher, (4) discussing, and (5) reading.

Distribute the papers and tell the children to write their names on the papers. Then ask them to write the number of the picture that shows what happened *most* during the science session on that day (or during the last week). Some children may wish to write more than one number. Tell them they may choose two pictures; listing more than two is less effective.

Collect the papers. Did the class express a consensus? Compare the results with your own impressions. If you find that most pupils identified the picture of children listening to the teacher (3), they may feel they were not active participants in the discussion.

If many or most of the children perceive a different emphasis than you intended, review "Helping Children Learn with SCIIS" (page xvi) and the "Teaching Suggestions" in the next few chapters, to help you plan future science periods.

You may also use "Our Science Class" to assess the children's preference among the different kinds of activities. To do this, ask them to identify the picture that shows the kind of activity they like best.

Glossary

The definitions in this glossary are intended for your use and quick reference. We do not recommend that you use them verbatim to answer children's questions.

abdomen–the posterior section of the body of an insect.

aged tap water– tap water that has been standing in an open container at least two days, allowing chlorine to escape.

animal-eater–an animal that uses other animals as a food source; usually a predator.

antenna–one of the jointed appendages occurring in pairs on the heads of insects (such as crickets).

aquarium–a container of water in which water-dwelling plants and animals live.

aquatic–living in water.

barrier–any object or condition that prevents dispersal.

biotic potential–the theoretically largest possible increase in any population of organisms if one assumes a maximum number of births and no deaths.

controlled experiment–an experiment consisting of at least two setups that are alike in all ways but one—the variable whose effect is being investigated.

decay–the breakdown of organic material due to the digestive action of microorganisms such as molds, bacteria, and yeasts.

development–passage from one stage of maturation to the next, recognized by the appearance of new structures such as flowers on plants. (See *growth*.)

dispersal–the random movement of organisms in various directions.

environment–the combination of all external factors that affect and influence the growth, development, and reproduction of organisms.

evidence– an observable effect that is used to justify a conclusion. For instance, a child may cite the appearance of green water in aquariums kept in the light as evidence that light turns water green.

feedback–information that comes to a person as a result of something done by that person. A child's answer to your question provides you with feedback about earlier instruction.

food chain–a concept that can be diagramed to depict the food relations among plants, plant-eaters, and animal-eaters. For example:
wheat → crickets → frogs → raccoons.
A food chain may consist of only a plant and an animal population that eats it. For example:
corn → humans.

food web–two or more interconnected food chains.

germinate–to begin to grow; to sprout.

growth–increase in size. (See *development*.)

habitat–the place in the environment where a particular organism normally lives.

larva–the first state after hatching of an animal that undergoes metamorphosis.

life cycle–the sequence of changes as an organism develops from an egg to an adult, which in turn produces eggs or sperm that give rise to the next generation.

organism–an individual living thing; any plant or animal.

plant-animal-eater–any animal that uses both plants and animals as a food source.

plant-eater–an animal that uses plants as a source of food.

population–a group of organisms of the same kind living and reproducing in a particular area. Population size is determined by the number of individuals in the group and not by the physical size of the individuals.

predator–an animal that captures and eats other animals.

prey–an animal that is caught and eaten by another animal.

reproduction–the process by which new members of a species are produced.

sprout–to begin to grow, as from a seed or bud.

terrarium–a container of soil in which land organisms can live.

variable–a condition that can differ from one experiment to another.

SCIIS Plants and Animals

The organisms used in the SCIIS life science units have been chosen for their resiliency and ease of maintenance as well as their behavior, feeding relationships, and life cycles; no complicated feeding or housing arrangements are required. Nevertheless, some preparations for the arrival of organisms are necessary. Aquatic organisms, for instance, need aged tap water, in which the chlorine content is reduced below the level that is harmful to the organisms. Terrestrial organisms need a container with plants or animals that serve as food. On the following pages you are given both background and maintenance information on the plants and animals studied in this unit, as well as general information on planning and ordering procedures.

PLANNING THE UNIT SCHEDULE

Living organisms are the focus of the children's investigations in the SCIIS life science units. Ordering and maintaining the organisms during the teaching program are therefore important responsibilities for you and your pupils.

In planning to teach a life science unit, first examine the "Schedule of Activities" on the last page of this guide. The schedule identifies the activities in the unit and indicates the approximate time required for each one. Also indicated are the times when organisms should be ordered. Use the schedule along with the following instructions to make sure that you receive living organisms when you need them.

ORDERING LIVE ORGANISMS

The seeds and live organisms for SCIIS are to be obtained through Rand McNally & Co. In each kit you will find an envelope containing one or more forms to be used in ordering the organism shipments.

What to order. The contents of the *Populations* shipments are as follows:

- P-1 Algae, daphnias, aphids.
- P-2 Crickets, chameleons.
- P-3 Algae, damselfly nymphs, snails, daphnias, hornwort, *Wolffia*.

When to order. As you proceed through the Teacher's Guide, watch the "Getting Ready" notices—you will be reminded to send in each order form well in advance of the time when you will need the shipment. It is very important to you and the children that the organisms arrive on time: *You must make sure that the order is mailed three weeks before the shipment is needed.* This is because we must not only process the order, package the shipment, and allow time for shipping, but in some cases must also assist the animals. For example, the frog eggs in *Life Cycles* must be squeezed out of females, fertilized by sperm, and checked for viability just before shipment. Other organisms must be carefully selected so that they will be the correct age and size and in proper condition for use in the classroom.

How to order. Complete the order form for the shipment, including the date when needed, your name, and the school's exact address. Do *not* have these shipments sent to your district's central supply department or warehouse! The arriving organisms will need your care immediately and must not sit on a shelf. To prevent your shipment from being treated casually when it arrives at your school, forewarn the mail or package sorter of its impending arrival and firmly request that you be notified as soon as it is received. Too many organisms have died in their shipping containers after languishing for a week under a counter, only a few doors away from the waiting children.

Preparing for arrival. The preparations necessary for SCIIS organisms are minimal, but they are important. The sooner you can get the organisms out of their shipping containers and into their proper habitats, the better for the organisms.

Before any organisms arrive, tell the children that in handling the plants and animals, they should be as careful as they would be with their own pets: they must not harm any organisms, and they must avoid being harmed. No SCIIS organisms will harm them, but the children should keep their hands away from their faces while working with the organisms and wash their hands afterward.

Water. Water to be used in aquariums can usually be taken from the tap, but you should not put organisms into tap water immediately. "Age" it by leaving it uncovered for at least two days to allow the chlorine to escape. If you age water in 1-gallon jugs with small necks, be careful not to fill the jugs completely, or the water's top surface area will be too small for rapid exchange of gases. To begin *Populations* you will need to age about 4 liters (1 gallon) of water in fluted containers.

Another source of water is spring water from a grocery store or a bottled water company. Do not confuse spring water with distilled water—they are different! We do not advise using distilled water, because it is not supposed to contain any chemicals other than pure water. All animals need certain elements that are always present in spring, pond, or tap water.

Sand and soil. These items are provided with the equipment kit and have been carefully chosen for suitability with the organisms and equipment in the program. Sand to be used in an aquarium must be rinsed of dust so the aquarium water will remain

clear: half-fill an aquarium with sand; add water while stirring the sand; and pour off the cloudy water. Repeat these steps until the water remains clear after the sand has settled. If you wish, let that water remain in the aquarium for two days; you will then have an aquarium containing both rinsed sand and aged tap water.

The soil has been premixed in the proper proportions for good growth and drainage, and it needs no further preparation.

Plants. In some units, arriving terrarium animals (such as the crickets in *Populations*) should have growing plants waiting for them. Be sure to plant seeds at least a week before you expect the shipment in such cases.

PLANTING SEEDS

The seeds are shipped with the kit and are available for your use as soon as you wish to begin the unit. You are probably familiar with the kinds of seeds used in SCIIS.

No seeds in the program contain toxic materials or have any associated with them. Because children may put seeds in their mouths, you should avoid using seeds sold for garden use—these may have been treated with toxic chemicals that retard mold growth. The SCIIS seeds have been selected for high viability: nearly all of them will germinate, provided that they are planted and watered properly.

The only common classroom problem children have with seeds is that the seeds do not germinate. This is often caused by excessive watering. Not watering will of course also result in no germination, but that problem is unlikely in a classroom.

CARE OF PLANTS IN THE CLASSROOM

A classroom isn't always the best environment for plants. Your room may be very dry, cold, hot, bright or any combination of factors. But, by concentrating on the three environmental factors over which you can have some control—water, light, and temperature—you will have success with the plants we have selected.

Before beginning the unit decide where you will grow the plants, keeping in mind the amount of light, temperature, and drafts. Also consider whether the plants will be bumped into often, and if the children will be able to observe them easily. Using the following list will help you to find the best place for your plants and to give them good care.

Water.

- The amount of water is the *most* important environmental factor for plant development and growth. While classroom temperature and light variations can speed up or slow development and growth, excessive water variations quickly *kill* plants. A fast- or slow-developing plant is infinitely better than a dead one!
- Use enough water to darken the soil.
- The soil is too wet if (1) you can squeeze water from a large pinch of soil, (2) you can see water in the planter base, or (3) a seed rots.
- The soil may be too dry if (1) a pinch of soil crumbles, (2) the seeds in it don't sprout, or (3) the seeds in it sprout later than seeds planted in moister soil.
- We can give no prescription for how much water should be given, or how often. Each classroom is different, and you must watch your plants' soil.
- The heat and low humidity in some classrooms cause plants and soil to dry out very rapidly. In such rooms avoid placing the plants in any drafts.
- For vacation periods place all the plants together, water liberally, cover with a large plastic sheet (a drop cloth or dry cleaners' bag), and leave the light source on (outside the plastic sheet) to help maintain the temperature above 10°C (50°F). Tell the custodian to leave the light on.

Light.

- Light is not needed until plant parts emerge from the soil.
- After emergence, the equivalent of a 100-watt bulb about 80 cm from the plant is sufficient for good growth.
- To estimate the proper height of the light source above the plants, hold your hand next to the plants. If the light shining on the back of your hand feels uncomfortably warm, raise the bulb. If your hand feels cool, lower the bulb.
- The light source supplied in the kit is adjustable. Use this feature for altering both the light intensity and the temperature.
- Whether the light is from sunlight or from the light source in the kit, the plants in this unit will grow. Natural light is better than artificial unless you have so much sunlight that the soil and plants dry out or become too warm. A table near the windows, but not in the draft of the heater or air conditioning fan, is a fine place for storing plants.
- Window sills are often problem spots. Depending on the time of year, they may be too hot, too cold, or too windy; or the shades and curtains may knock over the plants.

Temperature.

- 15 to 35°C (59–95°F) is the acceptable range. However, 20–25°C (68–77°F) is best.
- If you use the light source provided in the kit remember that whenever the plant is receiving light it is also absorbing heat from the bulb, and the

plant may be much hotter than the room. Adjust the lamp height as necessary.
The heat from any source of light may cause the soil to dry out, which is critical. Water is more important to plants than either light or heat.

Possible plant problems. In spite of your conscientious care, you may have trouble with seeds or plants. If you do, use this checklist to analyze the problem.

A CHECKLIST OF PLANT PROBLEMS

Failure of seeds to develop.

___ Too much water causes rot. Dig up one seed. If it is rotten discard the seeds, let the soil dry out, and start over.

___ If too little water has been added, the seeds will be unchanged from when they were planted. Water the soil thoroughly after replacing the seeds, and be sure they are not receiving too much heat.

___ You may not have waited long enough. Some seeds are slower to develop than others, though the kinds of seeds provided in the kits should sprout within nine days. Seeds will develop slowly if they are cold or haven't received enough water.

___ The seeds may have been planted too deeply, or the soil may have been pounded down on top of them. If you think this is the problem, dig the seeds up and plant them again.

___ In any group of seeds, a few will fail to develop. Assume 9 out of 10 seeds planted will develop, and be sure the children plant enough seeds to allow for this.

Animals on the plants or soil.

___ This usually occurs in overwatered plants. Reduce the amount of water given, and be sure none is standing in the planter bases.

___ Animals are free sources of live organisms—use them. They probably will show different life cycle forms. Aphids and gnats are common and will reproduce on plants and soil.

Blemishes.

___ Symptoms such as discolorations, leaf curl, and fuzzy spots on soil or plants are probably caused by molds or other fungi. Dry the plants out by watering them less and increasing the amounts of light and heat they receive.

___ Blemished plants will not necessarily die. To prevent infection of healthy plants, isolate the infected plants until they recover.

Breakage.

___ Protect plants from breaking by storing them where the children are not likely to knock them over or brush against them.

___ Allow only a few children to retrieve their plants at a time. This reduces jostling that might otherwise occur.

___ Encourage children to be gentle with the plants as they work with them.

___ Avoid storing plants near windy doorways or windows, where they might be blown over.

___ Use support sticks and ties for tall plants grown in pots.

Miscellaneous problems.

___ Sick-looking or dead plants may have lost too much water over the weekend. The solution is to water plants more on Fridays, or to cover them with waterproof plastic wrap, being careful the plastic does not break them.

___ Diseases are possible, but unlikely. Discard any diseased plants and plant new seeds.

___ Weak stems are usually caused by an overabundance of water, by the addition of more soil after the plant has sprouted, or by insufficient light. Have the children use less water, support the plants with sticks and ties, and be especially careful with these plants.

___ Kinked stems can be salvaged if they are kept straight with splints. Use yarn, tape, or a twistem to attach a stick or pencil to the weakened section of the stem.

CARE OF ANIMALS IN THE CLASSROOM

All the animals selected for use in this program will live in your classroom. However, we often find variations among classrooms that can cause some problems. Your room may be too dry, cold, bright, or hot for some of the animals. In many schools the heat is turned down at night and on weekends; some schools are dark; in others the blinds must be pulled down every afternoon; and some are in areas of very low or high humidity. Some rooms with a southern exposure heat up. Rooms with windows on the west side may have bright sunlight at four or five o'clock, after everyone has gone home—everyone but the SCIIS organisms, which are then literally in hot water. The next morning the water has cooled and everything looks normal, but many organisms are dead.

To prevent such disasters and the resulting disappointments for the children, set aside ten minutes to read the section beginning on this page, describing the key points in maintaining each of the animals. Environmental factors which can severely affect classroom animals are water, light, temperature, and food.

Water. As all the animals in this unit are aquatic, all you have to do is keep enough aged tap water in the aquariums.

Light and temperature.

- The presence or absence of light alone will not harm your animals. However, the light source also gives off heat that builds up inside animal containers.
- Check the temperature with the back of your hand, as described on page 87.
- For each animal, there is an optimum temperature, but none of the animals supplied will be harmed if you keep the temperature between 10°C (50°F) and 25°C (80°F).
- Temperatures below 23°C (75°F) will tend to slow the rate of development a little. But as with plants, an organism that develops too slowly is far better for your purposes than a dead one.
- When in doubt about whether to raise the temperature another degree or two, ask yourself whether there is danger of raising it too much if you forget to monitor the increase. If so, do not try to raise the temperature. Remember, this unit *cannot* be taught without live organisms.

Food.

- Daphnias eat algae, and snails feed on plants and detritus in the aquarium. You do not need to provide food for them under ordinary conditions.
- A continual supply of plants or seeds is needed for crickets.
- Chameleons eat crickets and other live insects.
- Provide daphnias for the damselfly nymphs.

PLANT AND ANIMAL SHIPMENTS FOR *POPULATIONS*

Algae

Receiving the organisms. When the shipment arrives, shake or swirl the container, then look at the liquid to see if it is green. If it is not, call the telephone number given with the shipment and request a replacement.

Pour the contents of the shipping container into an aquarium of aged tap water and place the aquarium near a natural or artificial light source.

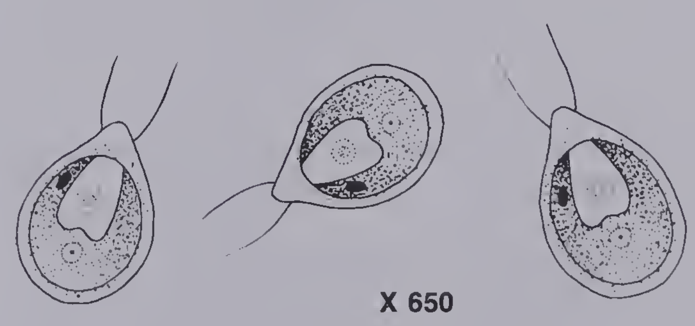
Classroom care and maintenance. The SCIIS algae ('al-[ı]jē) grow best at room temperature (15–25°C, or 60–80°F), in aged tap water having a large surface area for absorption of air. Some substances, including those in the plant-minerals concentrate provided for this unit, accelerate algal growth. Even without the addition of special minerals, however, algae may grow. For that reason you should not place an algae aquarium in a strong light unless you are trying to promote overgrowth. You can place it within the lighted area around a SCIIS light source, but not too close to the bulb.

Description and natural history. Like all other green plants, algae have the ability to photosynthesize—to manufacture food from carbon dioxide, minerals, and water, using energy from the sun. But, unlike many other plants, algae do not have roots, stems, leaves, or flowers.

The algae you receive are microscopic; however, a large population in an aquarium will give the water a green color. Other kinds of algae may be seen as dense layers of green filaments floating on the surface of ponds and ditches or attached to rocks in a stream.

The algae used in the SCIIS program live in freshwater ponds and are food for many organisms.

Figure L-1. Green algae as seen through a microscope.



Disposal. Being food for snails and other animals, algae are unlikely to cause any problems of disposal—they will be eaten. If you do wish to dispose of an algae aquarium, first pour the water into a

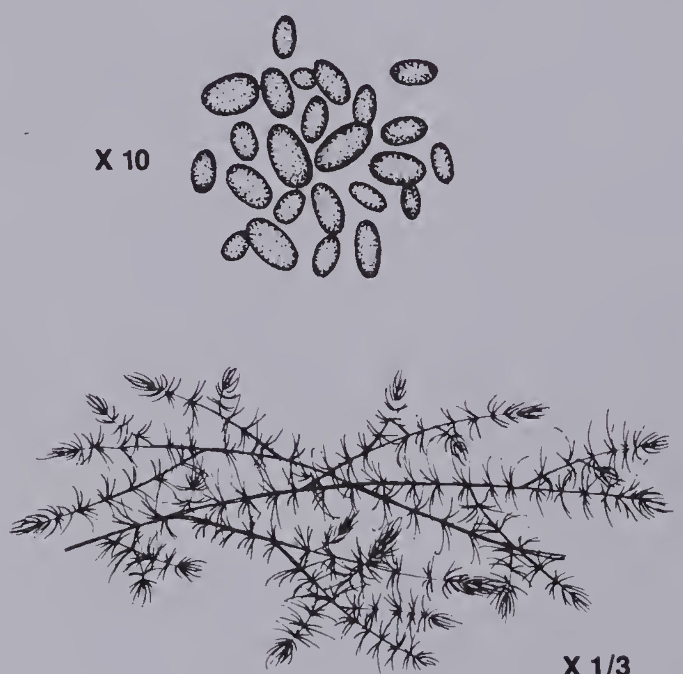
sink drain. Then, with the tap water running, scrape the aquarium walls with a wooden stick, rinse the walls, and discard the rinse water. Wipe the aquarium out with a rag or paper towel.

Other aquatic plants. In addition to algae, the *Populations* aquariums contain hornwort *(Ceratophyllum)* and *Wolffia* ('wůlfēə).

Receiving the organisms. When Shipment P-3 arrives, remove the cover of the *Wolffia* shipping container and pour the contents through a strainer if one is available. Then transfer the plants to a container of aged tap water. Discard any plants that are not bright green or that have a bad odor. Place the container near a light source. The *Wolffia* container should be opened on the day of arrival.

The plastic bag containing snails and hornwort should also be opened immediately and the organisms dropped into aged tap water. (Rinse the hornwort first.)

Figure L-2. *Wolffia* (*above*) and hornwort (*below*).



Classroom care and maintenance. Like algae, these aquatic plants require moderate light and a 15–25°C (60–80°F) temperature.

Description and natural history. *Wolffia* plants are very small, green, and rootless. They float on the surfaces of ponds and lakes as a green mat, where they provide a favorite food for waterfowl. New fronds bud from old ones when the plant reproduces. Tiny flowers may be formed, but this happens only rarely.

Hornwort has bushy stem tips, which account for the plant's other common name of coon tail. Leaves are arranged in spiral fashion around the stem. When flowers and fruits form, they are seen as small red cylinders. Muskrats and birds feed on these plants.

Disposal. To dispose of excess plants, wrap them in a towel and discard.

Daphnias.

Receiving the organisms. When you receive the daphnias('daf-nē-əz), pour the contents of the shipping container into a dip net, discarding the liquid. Then turn the dip net inside out, submerge it in a culture of algae you have prepared, and wash the daphnias from the net.

Classroom care and maintenance. Though daphnias do not require light, algae do. Light that produces good algal growth will also benefit the daphnia population.

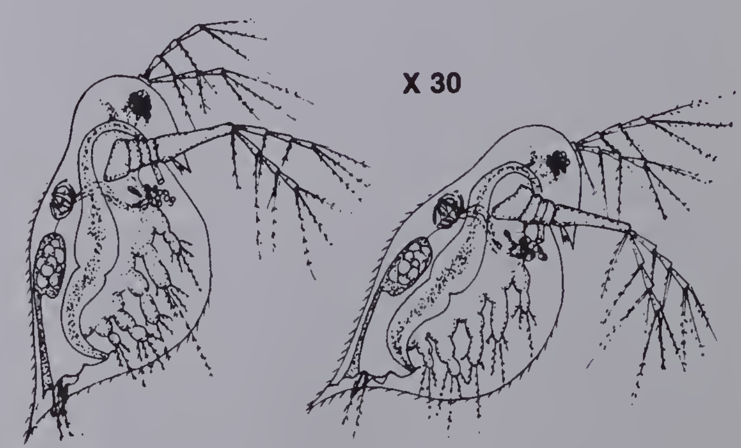
Place the culture of algae and daphnias near enough to the light source that the light shines onto the water, but not too near: the culture can easily become too hot. The optimum temperature range is 20–25°C (65–80°F). (You can estimate the temperature at any given point under the light source by placing your hand there. If the light shining on the back of your hand feels uncomfortably warm, the temperature there is too high for other organisms as well. Similarly, if your hand feels cold, that place is probably too far from the light.) Adjust the height of the light bulb or move the aquarium to the side if the water gets too hot. Above or below their temperature range, the animals will die, or they will produce special black egg cases rather than live young.

If you wish to maintain a culture for several months, transfer some daphnias to a fresh container of algae water every two or three weeks.

Description and natural history. Daphnias *(Daphnia)*, also called water fleas, are small aquatic animals related to lobsters, crayfish, and crabs. The animals can often be found in freshwater ponds, lakes, or slow-moving streams, where they feed on algae and decaying organic material.

The shell (carapace) and some of the organs are

Figure L-3. Daphnias.



transparent. The vibrating legs, the single black eye, and the intestine (usually filled with green algae) show through the carapace. These parts, as well as the two large antennae which are used for swimming and which are not enclosed by the carapace, can be seen with a magnifier.

When fully grown a daphnia is about 3 mm long. It grows in distinct stages rather than showing gradual and uninterrupted increase in size. Its rigid carapace is cast off periodically and, as the animal grows, a new and larger carapace forms and hardens.

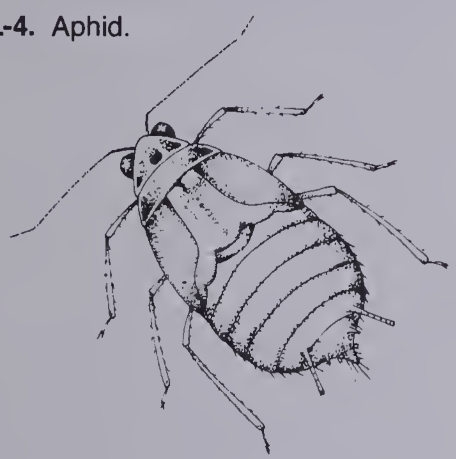
Most daphnias are female and can reproduce without fertilization. Ten to twenty eggs appear in the brood pouch every few days. These eggs quickly develop into tiny daphnias inside the pouch, and the young are released live. The young grow rapidly and soon produce eggs of their own.

Disposal. After the unit is completed, any remaining daphnias can be used as an excellent fish food.

Aphids.

Receiving the organisms. The aphids (ʼā-fədz) will arrive on a seedling in one or more taped containers. Remove the tape and check the plant for moisture. Add water if necessary. Place the container, without a top, where it will not be disturbed and where the plant will receive some light. Any aphids that have fallen off the plant will climb back on. Check the plant every day and water it if necessary.

Figure L-4. Aphid.



X 14

If the plant is to be removed for transplanting, use a tweezers or forceps. Carefully lift the plant out and transfer it to soil. Some aphids may fall off during this operation, but they will quickly go back on the plant when put near it.

Plan to transfer the aphids you receive in Shipment P-1 to the pea plants as soon as possible. If the plants are not above the soil when the shipment arrives, the aphids may be kept in their shipping containers for about one week.

Classroom care and maintenance. Pea aphids require young, healthy plant seedlings on which to feed. Pea seedlings or broad bean seedlings are recommended. Plant new seeds at least once a week, so that there will be a continuing source of food plants. If the new plants are near those with aphids, some aphids will usually move to the new plants. If they do not, transfer a few individuals. Aphids survive best in an environment with high humidity and at a temperature of 20–25°C (68–75°F).

Description and natural history. The pea aphid is a small insect which lives on pea plants as well as on several other plants. Aphid mouthparts fit together to form a needle-like structure which is used to pierce stems or leaves and suck out plant juices. Some aphids have wings, others do not.

During the spring and summer, usually only female aphids can be found. During these seasons, all adult females can produce eggs that do not require fertilization in order to develop into young aphids. The young develop inside the body of the female and are born live. After emerging from the mother, the young soon attach themselves to a stem or leaf and begin feeding.

All newly born aphids are wingless and are quite similar in appearance to adults. They molt at intervals and grow until they become adults. The discarded skins are white and can be seen easily.

Healthy aphids reproduce rapidly on certain species of plants. If a plant becomes overcrowded aphids may develop wings. The winged aphids usually disperse; if they find another suitable plant they will alight, feed, and produce young.

Disposal. Unwanted aphids can be washed down the drain.

Crickets.

Receiving the organisms. Crickets may die or begin eating each other if kept in the shipping container. If you cannot distribute them to the children within one day, shake them into two of the terrariums. If the plants have not germinated, sprinkle some mustard, clover, or grass seeds on the soil surface.

Classroom care and maintenance. Crickets can be maintained in the terrariums the children have built provided there is a dry area available. (A crumpled paper towel placed in the terrarium will provide an adequate dry area.) The best temperature is between 24–27°C (75–80°F). Food is essential; if the terrariums contain no growing plants, sprinkle seeds on the soil. Crickets can also be fed oatmeal, corn, or bran flakes or shredded wheat.

Description and natural history. Crickets are large-headed insects with a body length of about 2.5 cm (1 in). They are usually brown, have two pairs of wings, and have two long antennae at the front of the head.

In both sexes there is a pair of short spines at the rear of the abdomen. The female also has a long, slender ovipositor (an egg-laying tube) extending from the rear of the abdomen.

The female may frequently be seen laying eggs in

Figure L-5. Cricket (male).

the moist soil of the terrarium. She forces her ovipositor into the soil and deposits her eggs, which usually hatch in two to three weeks. Mating is not necessary prior to each egg laying, because the female can store sperm for long periods of time.

The life cycle of the cricket consists of three stages: egg, nymph, and adult. About 18 days after they are deposited, the eggs hatch into nymphs, which look like tiny wingless adults. Depending on a number of factors such as temperature and moisture, it takes about four to eight weeks for a nymph to become an adult.

Upon reaching adulthood, the male cricket is able to chirp by rubbing a hind leg and a wing together. Chirping is thought to attract females and establish territories.

Disposal. Crickets are excellent food for salamanders, frogs, and toads. If other teachers in your school are using the SCIIS *Communities* unit, they would probably be happy to have your extra crickets. Otherwise, place the crickets in a plastic bag, freeze, and discard.

Chameleons.

Receiving the organisms. Keep the chameleons out of the children's sight for about a week. When the chameleons arrive, add them to a prepared terrarium, which should also contain a crumpled paper towel. Empty the chameleons and moss into the terrarium together. Use a water sprinkler to spray water on the inside walls of the container. Add water frequently, as it is the chameleon's only source of moisture. The chameleons will not require any food before being introduced to the children's terrariums.

Classroom care and maintenance. The temperature should be maintained at 19–25°C (65–75°F). The chameleons will feed on crickets. However, if you run out of crickets, they will eat other live insects. Large mealworm larvae have a chitinous shell that chameleons cannot digest, and so these larvae should not be used. The smaller, paler larvae are an excellent food for chameleons.

Be sure to spray water on the inside walls of the terrariums daily.

Description and natural history. American chameleons are small long-tailed lizards, native to the southeastern United States. The body length of an adult is about 65 mm (2½ in), and the tail is about twice the length of the body. The chameleon has suction pads on its toes that enable it to hang onto smooth, vertical surfaces.

The male has a prominent throat fan that is frequently displayed as a warning flag to threaten enemies or other males that approach. This bright red or pink fan is a loose fold of skin which is spread by the downward and forward movement of a flexible cartilage just inside the skin.

Chameleons change color as a result of changes in seasons, temperatures, amount of light, and color of environment.

Eggs are laid in the summer and are buried just below the surface of the soil or in loose debris. The eggs are soft and hatch in six to seven weeks. The parents do not take care of the young.

Chameleons consume great quantities of insects. They drink water that has condensed on plants as droplets or has been sprinkled on surfaces.

Disposal. If parents permit, let children take them home; or give them to another teacher. Otherwise, place in a plastic bag, freeze, and discard.

Figure L-6. Chameleon.

Damselfly nymphs.

Receiving the organisms. Pour the contents of the shipping container into a container of aged tap water. Check to see if the nymphs are alive by touching them with a pipe cleaner; any that fail to move are dead and should be removed. Add several sprigs of hornwort to the container. The larvae do not require any food before the children add them to the aquariums.

Classroom care and maintenance. The children's aquariums are excellent habitats for damselfly larvae as long as there are aquatic plants and an adequate supply of daphnias for food. The temperature should be kept between 18–24°C (65–75°F).

Description and natural history. The nymph is the immature stage (larva) of the damselfly, a close relative of the dragonfly. Damselfly nymphs live in water and feed on small aquatic organisms, such as daphnias. Their mouthparts are modified into a peculiar structure with which the nymph captures prey.

This structure is thrust forward very quickly, and the prey is seized by two movable, clawlike lobes. At the end of the abdomen there are three leaflike structures. These are gills that are used for breathing.

Just before transforming into a winged adult, the nymph crawls out of the water, usually onto a plant stem or rock, and undergoes its final molt. Adult damselflies, which have two pairs of membranous wings,

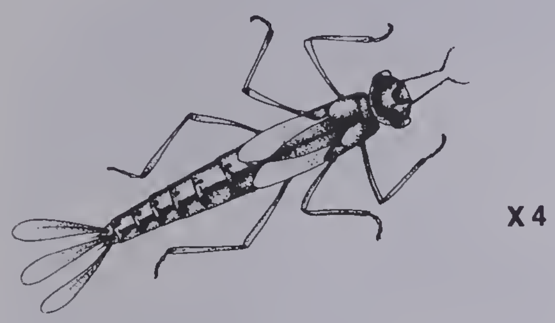


Figure L-7. Damselfly nymph.

feed on insects that they capture in flight. The adults are usually found flying in the vicinity of streams, ponds, and lakes.

If you teach this unit in the spring, some of your damselfly nymphs may become adults.

Disposal. Unless the damselfly larvae transform into adults, they will eventually die, decompose, and become part of the detritus in the aquarium.

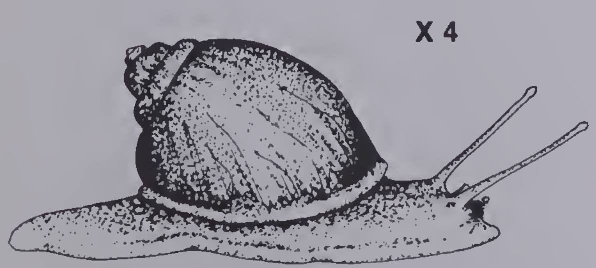
Pond snails.

Receiving the organisms. Be sure, when receiving a shipment of snails, to place them only in a container of *aged* tap water. (Though their shells may make them appear hardy, snails are sensitive to acidity and small amounts of certain compounds in tap water.)

Classroom care and maintenance. For normal classroom use, no special foods are necessary for the snails; they feed on algae and decaying material in the aquariums.

Description and natural history. Snails are frequently found climbing on plants, rocks, and other submerged objects; small ones can even be seen hanging suspended from the surface film of water. Snails are eaten by fish, ducks, and large insects.

Figure L-8. Pond snail.



The large soft part of the snail which protrudes from the coiled shell is called the foot. It consists mainly of muscle tissue and is the organ of locomotion. Usually snails move by creeping over a thin film of mucus deposited by the foot.

The head is located at the front of the foot and has two tentacles. On each tentacle is an eye. The mouth is on the lower surface of the head. Within the mouth there is a rasplike tongue which scrapes across the food material and reduces it in size for swallowing.

Most snails eat the soft tissues of plants, but some are scavengers that eat dead plants and animals. They will remove algae and detritus from the aquarium walls, making the contents more visible.

Snails lay eggs in gelatinous clumps on leaves, on sticks, or on other objects. Frequently you will find snail eggs on aquarium walls. Tiny snails, looking very much like the adults, crawl out of the jellylike mass after one or two weeks.

Disposal. When you have finished with them, pond snails will make a good addition to aquariums in other classrooms. If they must be killed, put them in a plastic bag and freeze them.

Design and Use of the Kit

The equipment kit has been designed to help you teach the unit effectively. Except as noted below, all materials needed for a class of thirty-two students have been included. The items are packaged for convenient removal, use, and reuse. In response to feedback from users of SCIS, we have placed a contents list on the front of each drawer. In addition, the chapter "Teaching Materials" lists are now arranged by drawer number.

Familiarize yourself with the entire kit as well as with the diagram and lists on this page. You should inventory the kit before beginning to teach the unit, using the lists on this page for checkoff and notes.

Drawer 1, containing the printed materials, is a separate box. Place it on top of the kit as indicated in the diagram.

Some common items are to be provided by the teacher. The "Teaching Materials" list for each chapter indicates what you are to provide, and the "Getting Ready" notices give you advance warning about these items when necessary.

The live organisms studied in this unit are not included in the kit. Instead, they will be sent separately when your completed order forms are received. Complete directions for ordering are on page 86.

Drawer	Item Description and Quantity
1	1 Teacher's Guide 32 student manuals 2 sets of Extending Your Experience cards and display box 1 evaluation envelope 1 Daphnia chart 1 Daphnia graph 1 Aphid chart 1 Aphid graph 1 Biotic Potential chart: Daphnia 1 Biotic Potential chart: Beans 1 Populations picture 32 small Populations pictures 1 Aquarium Populations chart 1 sheet colored dots
2	42 vials with caps 16 magnifiers 1 light source 4 trays 16 vial holders 1 set of Live Organisms Shipments order forms
3	20 tumblers 1 roll labels 90 twistems 16 medicine droppers 32 wooden sticks 16 daphnia counters 1 package pipe cleaners 8 pieces of plastic tubing 8 plastic tube holders 7 plastic bags
4	4 six-liter containers 8 container lids 1 baster 16 fluted containers 1 dip net 1 vial brine shrimp eggs 1 package noniodized salt

Drawer	Item Description and Quantity
5	4 six-liter containers 48 planter cups 48 planter bases 2 packages clover seeds 3 packages pea seeds 2 packages bush bean seeds 2 packagés fava bean seeds 1 package grass seeds 1 package mustard seeds 32 planter sticks 4 water sprinklers

Sand and Soil box

2 bags of soil
1 bag of sand

Live Organisms Shipment P-1

2 containers green algae
200 daphnias
100 aphids

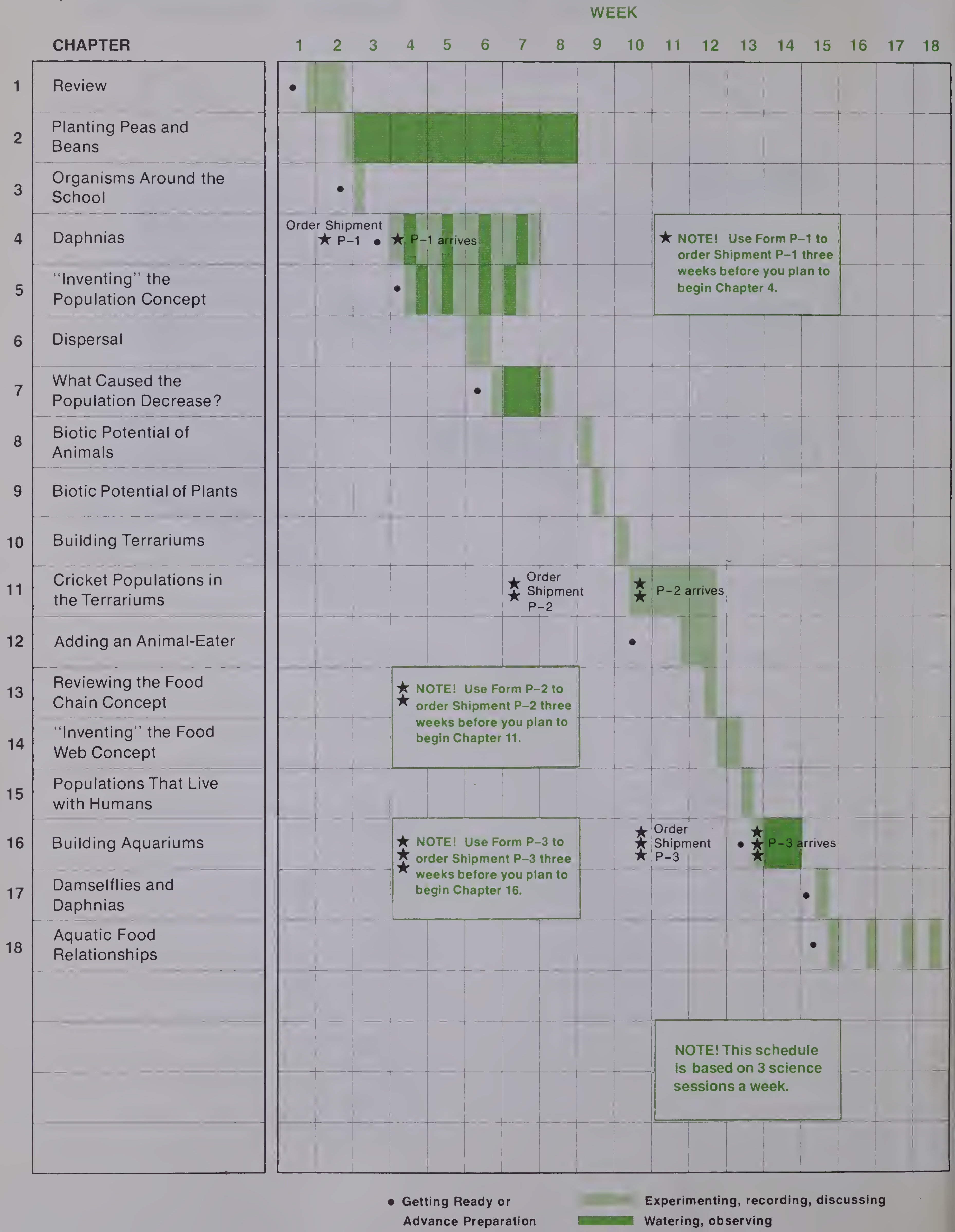
Live Organisms Shipment P-2

80 crickets
7 chameleons

Live Organisms Shipment P-3

1 package hornwort
1 jar *Wolffia*
200 daphnias
18 snails
16 damselfly nymphs
1 container green algae

Populations Schedule of Activities



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RAND McNALLY
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